Instrumentation

Instruction Manual for

Model 7100A

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Integrating Digital Meter

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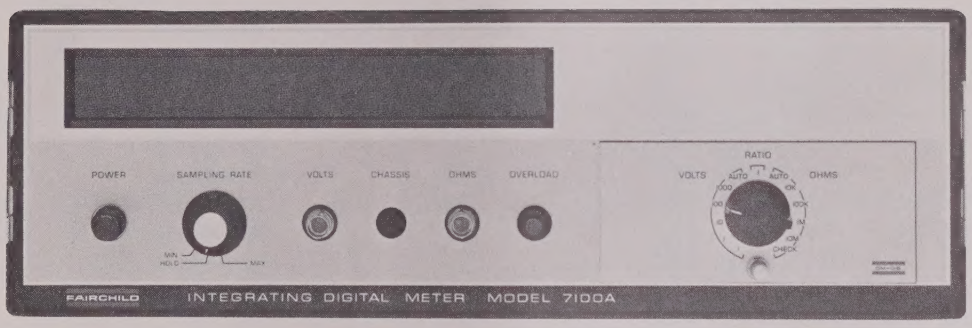
Instruction Manual for

Model 7100A



SERIAL NUMBER

Integrating Digital Meter

FAIRCHILD
INSTRUMENTATION

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LIST OF EFFECTIVE PAGES

Model 7100A

Total number of pages in this manual is 158
consisting of the following:

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Additional copies of this publication may be obtained from:
Fairchild Instrumentation, 974 East Arques Avenue,
Sunnyvale, California 94086.

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FAIRCHILD INSTRUMENTATION
EQUIPMENT WARRANTY

Seller warrants equipment of its manufacture against defective materials or workmanship for a period of one year from date of shipment.

The liability of Seller under this warranty is limited, at Seller's option, solely to repair, replacement with equivalent Fairchild equipment, or an appropriate credit adjustment not to exceed the original equipment sales price, of equipment returned to the Seller provided that:

a. Seller is promptly notified in writing by Buyer upon discovery of defects,

b. The defective equipment is returned to Seller, transportation charges prepaid by Buyer, and,

c. Seller's examination of such equipment discloses to its satisfaction that defects were not caused by negligence, misuse, improper installation, accident, or unauthorized repair or alteration by the Buyer.

This warranty does not include mechanical parts failing from normal usage nor does it cover limited life electrical components which deteriorate with age such as vacuum tubes, chopper, lamps, etc. In the case of accessories, i.e., card punches, typewriters, etc., not manufactured by the Seller, but which are furnished with the Seller's equipment, Seller's liability is limited to whatever warranty is extended by the manufacturers thereof and transferable to the Buyer.

This warranty is applicable to the original Buyer only and constitutes the sole and exclusive warranty of Seller. No other warranty is made, expressed or implied.

Section I
General Information

1-1. INTRODUCTION

1-2. This manual provides information for operation and maintenance of the Model 7100A Integrating Digital Meter. Sections II and III provide installation and operational information. Section IV describes theory of operation. Section V outlines periodic maintenance and alignment procedures, and Section VI lists replaceable parts and recommended spares.

1-3. DESCRIPTION

1-4. The Model 7100A, shown in figure 1-1, provides accurate measurement of dc voltage, voltage ratios, and resistance. A dual slope integration technique is used to minimize the effects of noise on the input signal and eliminate long term drift due to variation in component values in the measuring circuits. The instrument is self-contained, and may be used on a bench top or mounted in a rack with optional rack mounting hardware. Visual readout is provided by 5 numeric indicator tubes. Decimal point placement and polarity are automatically selected. The Model 7100A gives direct readout of voltages with full scale ranges of 0.1 volts, 1 volt, 10 volts, 100 volts, and 1000 volts. Resistance ranges are 10 kilohms, 100 kilohms, 1 megohm, and 10 megohms full scale. Voltage ratios from 0.0001: 1 to 1.0000: 1 may be measured in a single range of 1.0: 1. Each range is capable of a full 60% overrange (excepting the 1000 volt range).

1-5. Separate floating and guarded input connectors are used for voltage and resistance measurements.

Figure 1-1 Model 7100A Integrating Digital Meter

An additional rear connector is provided for voltage input in ratio measurements. Optional remote programing and data output provide remote selection of range and mode as well as BCD readout information and range/mode output. The standard plug-in unit (DM-01B) provides manual selection of range and mode. It also selects automatic voltage and resistance modes. An additional plug-in unit (DM-03A) provides high sensitivity ac to dc conversion.

1-6. The basic dual-slope integration technique operates as follows: a current proportional to the unknown input voltage charges a capacitor during a fixed period of time, determined by a crystal-controlled oscillator. The capacitor is then discharged by a second current proportional to a stable reference voltage. The time required to discharge the capacitor is proportional to the ratio of the unknown voltage to the reference. The number of oscillator cycles counted during the discharge time is displayed as the measurement result. This dual slope integrating technique eliminates the integrator and clock oscillator as critical circuits by cancelling out effects of long term variations.

1-7. OPTIONS

1-8. The following options are available to increase the usefulness of the Model 7100A:

a. Option 02. Provides 500 kHz clock oscillator for maximum normal mode rejection on 50 Hz power.

b. Option 03. This option provides remote programing of range and mode, and BCD output for remote readout or printer. Output lines 1-2-2'-4 BCD, "0" level +0.5 volts, "1" level +30 volts.

c. Option 04. Same as option 03, but output lines 1-2-4-8 BCD, "0" level +0.5 volts, "1" level +30 volts.

1-9. PLUG-IN UNITS AVAILABLE

1-10. The following plug-in units are available for use with the Model 7100A:

a. Model DM-01B. This standard plug-in (provided with instrument) selects manual ranges of 0.1, 1, 10, 100, and 1000 volts; 10 k ohms, 100 k ohms, 1 and 10 megohms; voltage ratio 1.0:1. The unit also selects automatic ranging on voltage and resistance measurements.

b. Model DM-03A. This unit measures ac voltages in conjunction with the Model 7100A. The DM-03A converts an unknown ac input voltage to dc voltage equivalent to the rms value of the input signal. The dc signal is then measured by the Model 7100A.

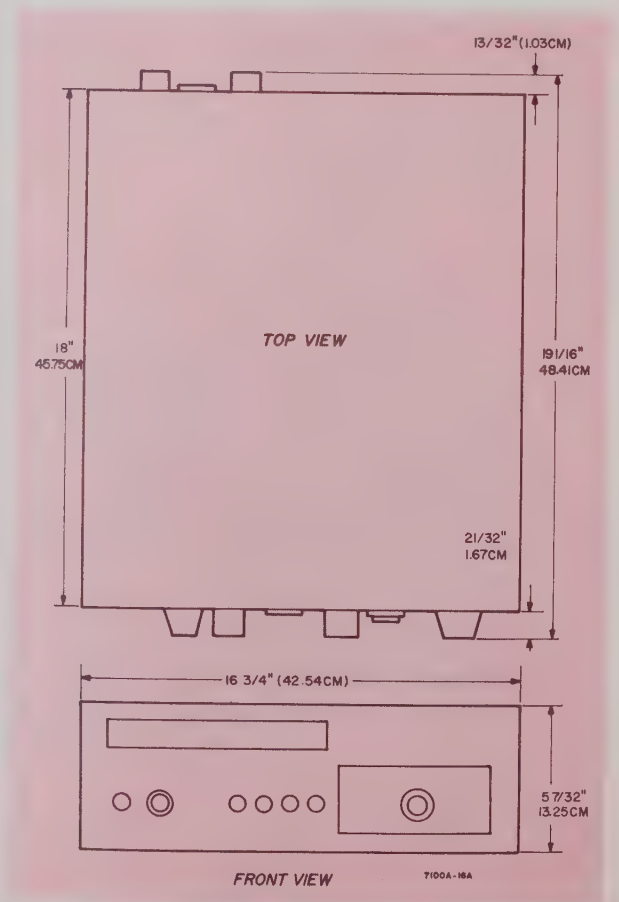


Figure 1-2 Model 7100A Outline and Dimensions

1-11. ELECTRICAL SPECIFICATIONS

1-12. Table 1-1 lists electrical specifications for a Model 7100A fitted with standard DM-01B plug-in unit. Electrical specifications for optional plug-in units are contained in the instruction manuals for these units.

1-13. DIMENSIONS AND WEIGHT

1-14. Figure 1-2 is an outline drawing of the Model 7100A showing principal dimensions in inches and centimeters. The weight of the instrument with Model DM-01B plug-in unit is 27 lbs. (12.3 kg).

Table 1-1 Specifications

DC VOLTAGE MEASUREMENT

Ranges:	± 100.00 mV, ± 1.0000 V, ± 10.000 V, ± 100.00 V, ± 1000.0 V full scale. Full 60% overranging with no loss in accuracy on 4 lowest ranges; 10% overrange with no loss of accuracy on 1000 volt range.
Accuracy:	± 0.01% of reading ± 1 digit; 100 mV range ± 0.01% of reading ±2 digits.
Stability:	Internal reference ± 0.01% for 3 months.
Input Resistance:	> 1000 megohms; 100 V and 1000 V ranges 10 megohms.
Autoranging:	Operates on both dc volts and resistance. Upranges at 16000 and downranges at 01399.
Input Circuit:	Floated and guarded, may be operated up to ±500 V from chassis ground. Special 2-pin insulated BNC connector maintains guard shield at front panel. Separate banana jack for chassis ground.
Maximum Input:	1100 V can be safely applied to all ranges. Maximum input from GUARD to LOW input: ±50 V.
Measurement Time:	250 msec, rear panel switch provides fast setting of 50 msec on four high ranges.
Integration Time:	83 1/3 msec; 16 2/3 msec on fast setting. Controlled by a crystal oscillator.

Table 1-1 Specifications (Cont)

DC VOLTAGE MEASUREMENT (CONT)

Common Mode Rejection:	140 dB at dc, 120 dB at 60 Hz with up to 1000 ohms connected between either side of the source and the voltmeter input (short integration time). 140 dB at dc, 120 dB at all frequencies to 1 kHz with up to 1000 ohms connected from either side of the source and the voltmeter input (long integration time).
Normal Mode Rejection:	Greater than 20 dB at 55 Hz with 83 1/3 msec integration time, increases 20 dB/decade increase in frequency. Virtually infinite rejection at 60 Hz and its harmonics. The polarity indication is determined by the integrated input and is stable even in the presence of severe noise.

VOLTAGE RATIO MEASUREMENT

Range:	±1.0000:1 full scale. Full 60% overranging with no loss in accuracy.
Unknown Input:	± 1 mV to ± 16 V, input resistance > 1000 megohms.
Reference Input:	+5 V to +16 V, input resistance 3 kilohms, 30 V maximum input.
Accuracy:	+9 V to + 16 V; ±0.02% of reading ± 1 digit.
Measurement Time:	Same as dc volts.

RESISTANCE MEASUREMENT

Ranges:	10.000 kΩ, 100.00 kΩ, 1.0000 MΩ, 10.000 MΩ full scale. Full 60% overranging with no loss in accuracy.
Accuracy:	± 0.01% of reading ± 1 digit; ± 0.02% of reading, ± 1 digit on 10 megohm range.
Measurement Current:	1 mA, 100 μA, 10 μA, and 1 μA on the 10 kΩ through 10 MΩ ranges respectively.
Measurement Time:	Same as dc volts.

Table 1-1 Specifications (Cont)

READOUT	
Visual:	Amperex ZM-1030 numeric tubes; four full decades plus fifth digit gives full scale readout of 16000. Polarity, decimal point, and measurement unit are indicated.
Electrical:	See options.
OPERATING TEMPERATURE RANGE	10 to 50°C
TEMPERATURE COEFFICIENT	±0.0008% full scale, ±0.002% RDG/°C
POWER	
Standard:	105 - 125 V or 210 - 250 V selected by switch, 50 - 60 Hz, approximately 50 watts. (See Option 02 for special 50 Hz version.)
MECHANICAL	
Weight:	27 lbs. (12 kg); shipping approximately 36 lbs. (16 kg).
ACCESSORIES FURNISHED	
50303270	Power cable, 7 1/2 feet long.
50303310	Input cable, two furnished with each 7100A.
DM-01B:	Provides function control for the 7100A.
OPTIONS	
Option 02, 50 Hz Operation: 40033921	Crystal time base changed to give 1/50 and 1/10 second integration time for maximum normal mode rejection at 50 Hz.
Option 03, 122'4 BCD/Programing: 40038761	BCD/Programing provides:
a) BCD:	Positive True Logic. Numerals, decimal point, negative polarity, and function (dc volts, resistance, ac volts) indicated by a "0" state of +0.5 V and a "1" state of +30 V, 20 kΩ source impedance. Outputs are in 1-2-2*-4 binary coded decimal.

Table 1-1 Specifications (Cont)

ACCESSORIES FURNISHED (CONT)

b) Print Command:	+30 V pulse, 3.6 kΩ source impedance, 3 μsec maximum rise time, 3.0 msec minimum wi'th.
c) Programing:	Range and Mode controlled by external NPN transistor gate or contact closure to ground corresponding to selected switch position. A rear panel remote/ local switch selects the control point. Remote trigger providing up to 20 measurement samples per second, initiated by +10 V pulse into 20 kΩ, width 10 μsec minimum and 10 msec max.
Option 04, 1248 BCD Programing: 40038661	Provides programing function similar to Option 03, except that outputs are in 1-2-4-8 binary coded decimal.

Section II
Installation

2-1. INTRODUCTION

2-2. This section outlines procedures for inspection and initial installation. Reshipment instructions are included in the event that the instrument must be returned to Fairchild Instrumentation.

2-3. UNPACKING AND INSPECTION

2-4. As soon as the equipment is unpacked, inspect the instrument for damage in shipment. Check for scratches or dents and damaged knobs or connectors. Remove the top cover and be sure that all plug-in boards and indicator tubes are firmly seated in their sockets. If damage is noted, do not use the instrument unless instructed by the insuring agency.

2-5. POWER REQUIREMENTS

2-6. The Model 7100A is designed for use with 115/230 volts, 50 - 60 Hz, single phase, 3 wire power service. Before connecting the Model 7100A to the intended power source, be sure that 115/230 switch S2 on the rear panel is in the proper position.

2-7. Power Cord

2-8. The Model 7100A is supplied with a detachable 3-conductor power cable which is terminated with polarized 3-contact plugs. The offset round pin on the male plug is connected to the instrument chassis. If the instrument is to be connected to a 2-contact power outlet, use a 3-prong to 2-prong adapter and connect the pigtail on the adapter to ground.

2-9. 230 Volt Operation

2-10. To convert the Model 7100A for operation from a 230 volt power source, set switch S2 on rear panel to "230" position. Replace 1 ampere fuse F1 with 1/2 ampere fuse.

2-11. OPERATION CHECK

2-12. The following operational check may be used when the instrument is first installed. The procedure provides a quick check for proper functioning, but does not check specifications completely. For complete performance check, refer to paragraph 5-6.

a. Connect instrument to ac power source. Push POWER switch/indicator. Indicator lamp in switch housing should glow.

b. Set Range/Function switch to CHECK position.

c. Readout should indicate 10000 ± 1 digit after short warmup period.

2-13. RACK MOUNT CONVERSION

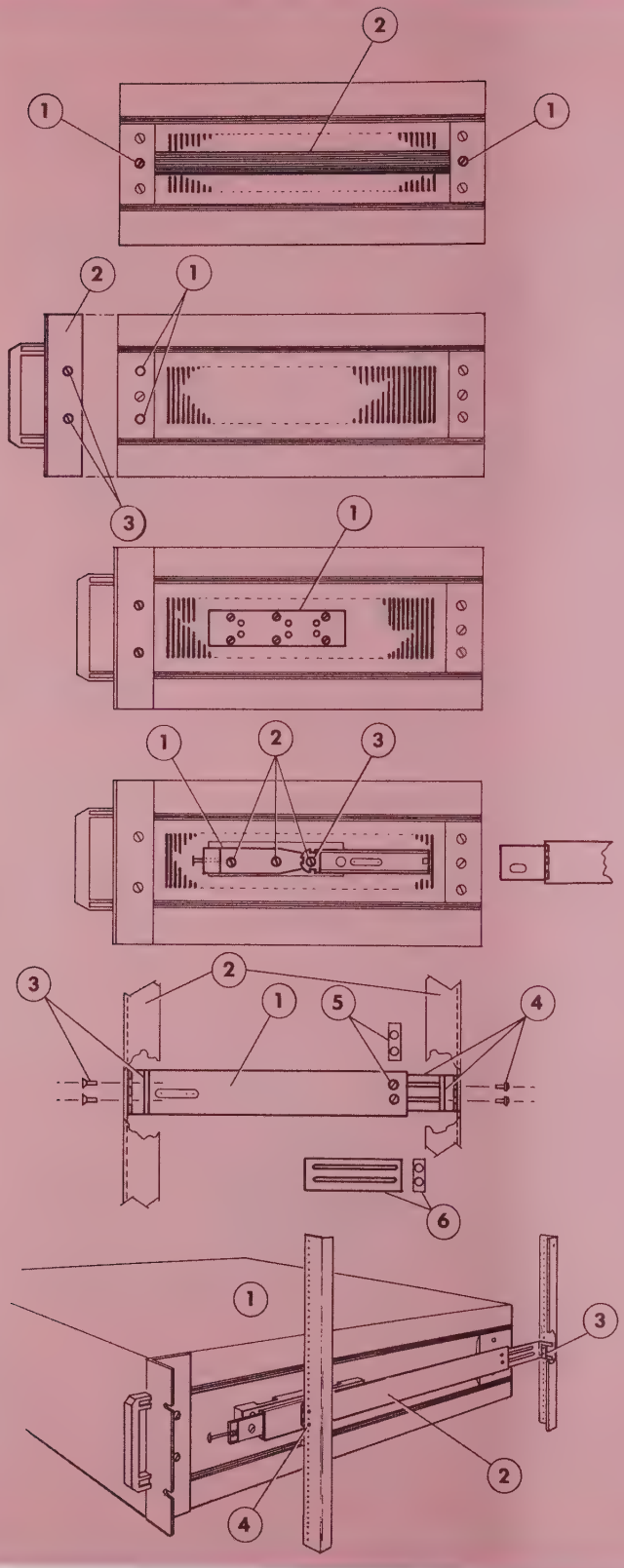
2-14. Detailed instructions for converting the Model 7100A to optional rack mounting configuration are shown in figure 2-1. Ordering information for rack mounting kits is listed in section VI of this manual.

2-15. RESHIPMENT

2-16. When an instrument is damaged in shipment,

do not return it to Fairchild Instrumentation without specific instructions from the insuring agency. Neither the customer nor Fairchild Instrumentation is required to assume responsibility for reshipment.

2-17. When an undamaged instrument is to be returned for service or repair, contact your nearest Fairchild Instrumentation engineering representative for shipping instructions.



a. Remove screws (1) and handle strap (2). Replace screws.

b. Remove screws (1) from front of instrument. Place rack handle (2) in position and replace screws with flat head screws.

c. Mount adapter (1) using six no. 4 screws. Note spacing on detail.

d. Remove center section (1) from slides. Mount adapter in lower set of holes using shoulder screws (2). Use screw with longer shoulder for pivot point (3).

e. Mount front of slide with flat head screws and bar nut (3). Mount angle bracket (4) using binder head screws and bar nut (5). If additional length is required use expander plate (6). Do not secure screws tightly at this time.

f. Place instrument (1) in rack (2) and insert fully into rack. Tighten screws (3) at rear. Withdraw instrument approximately six inches and adjust rack until it is level. Secure screws (4) on front.

Figure 2-1 Rack Mounting Instructions

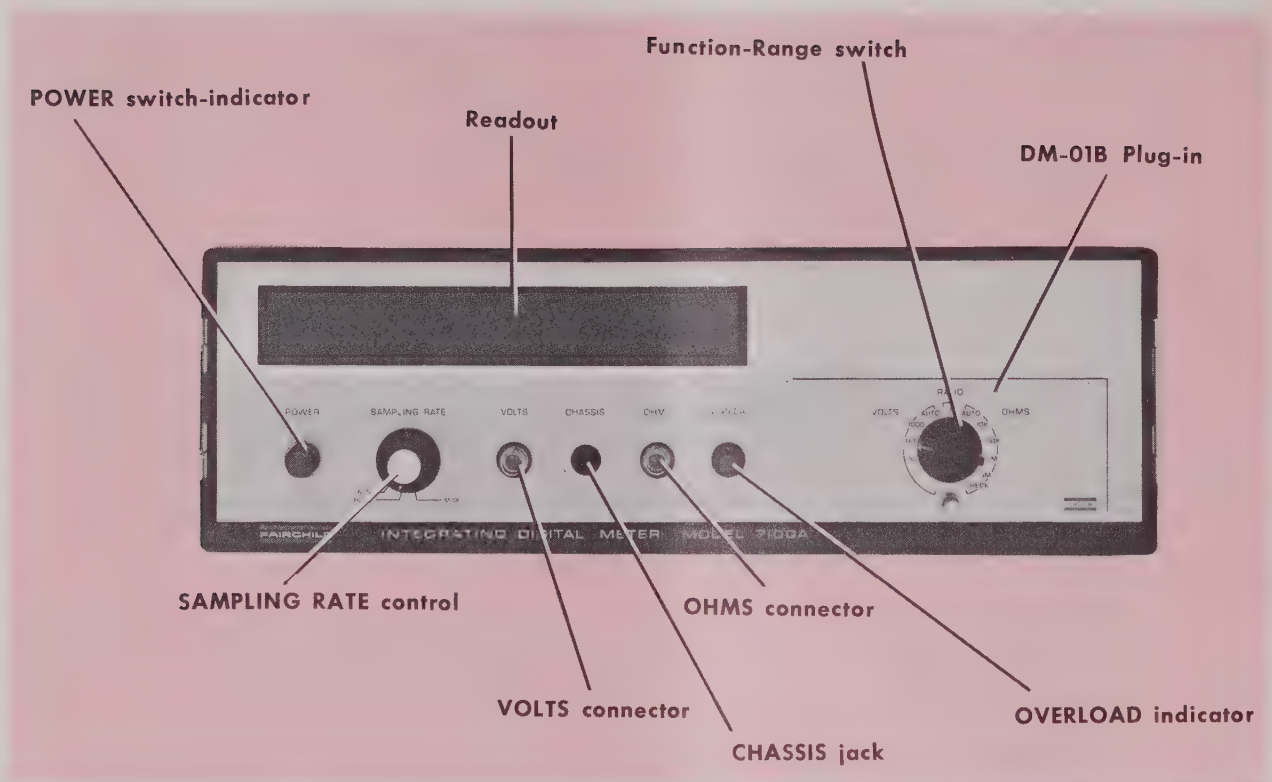


Figure 3-1 Front Panel Controls

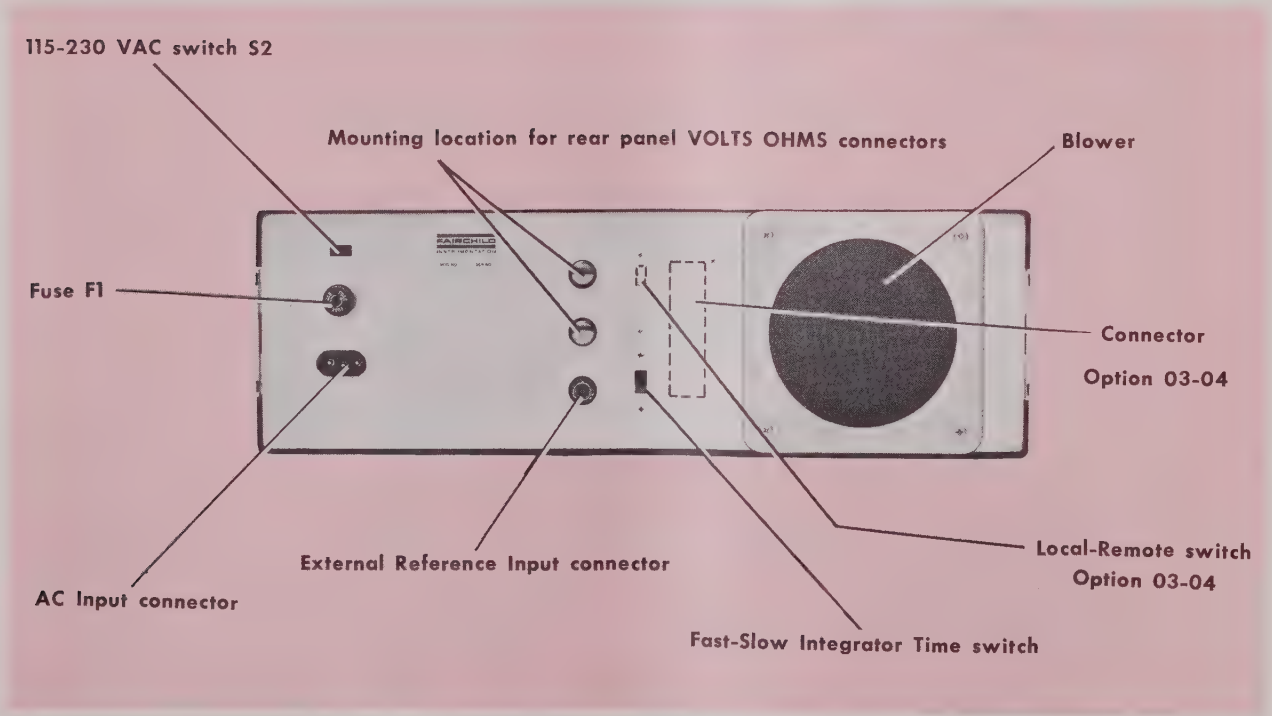


Figure 3-2 Rear Panel Controls

Section III
Operation

3-1. INTRODUCTION

3-2. This section describes operator controls and procedures for measuring voltage, voltage ratio, and resistance. Information concerning measurements with optional plug-in units is contained in the instruction manuals for these units.

3-3. OPERATOR CONTROLS

3-4. The following paragraphs describe the function of controls and indicators located on the front panels of the Model 7100A and DM-01B, (refer to figures 3-1 and 3-2).

a. POWER switch connects primary ac power to instrument. Indicator lamp in switch housing glows when primary power is applied.

b. SAMPLING RATE potentiometer controls recurrence rate of measurement cycle. Rate may be varied from one every two seconds (MIN position) to four per second (MAX position). In the detented HOLD position, the instrument holds the last reading indefinitely.

c. VOLTS connector is a special guarded connector (used with test cables supplied) for voltage and voltage ratio measurements.

d. OHMS connector is guarded connector used in resistance measurements.

e. CHASSIS banana jack is connected to instrument chassis and through the power cord to power line ground.

f. Function/Range rotary switch sets measurement mode and range as follows:

VOLTS	.1	±.10000 volts full scale
	1	±1.0000 volts full scale
	10	±10.000 volts full scale
	100	±100.00 volts full scale
	1000	±1000.0 volts full scale (maximum input voltage ±1100 V).
AUTO		Instrument automatically selects voltage range which places reading between 16000 and 01399 before starting measurement cycle.
RATIO	1.0	Ratio of dc voltage at VOLTS connector on front panel to dc voltage at J6 on rear panel. Full scale ±1.0000:1.
OHMS	10 K	10 kilohms full scale
	100 K	100 kilohms full scale
	1 M	1.0 megohms full scale
	10 M	10 megohms full scale.
AUTO		Instrument automatically selects resistance range which places reading between 16000 and 01399 before starting measurement cycle.
CHECK		A self-check feature which gives a readout of 10000 when instrument is operating correctly.

All positions of the Function/Range switch may be programed remotely (Option 03 or 04).

g. OVERLOAD indicator lights when input signal exceeds full scale plus overrange capability of instrument.

h. Readout gives measurement result: polarity, 5-digit numeric readout with decimal point placement, and measurement units. Polarity indicator is blanked in resistance measurements.

3-5. TEST CABLE

3-6. The input cable supplied with the instrument terminates in 3 banana plugs colored red, black, and white. The red plug is signal high, the black plug is signal low, and the white plug is connected to the guard (see figure 3-3). The other end is terminated in a special BNC plug which mates with the VOLTS and OHMS connectors on the front panel, as well as J6 on the rear panel.

3-7. The cable supplied with the instrument should be used at all times since a cable with inferior leakage characteristics may cause measurement errors. This is especially important on the highest resistance range where leakage of 15 kMΩ will cause a 1 digit error.

3-8. The 3 terminals on the cable should be used correctly to achieve the best rejection of common-mode signals. When measuring a low level, high impedance source with its own ground (bridge transducer, thermocouple, etc.,) connect the guard plug to the device ground and the high and low connections to the output terminals. For all other measurements, connect the guard and low terminals to one measurement point and the high terminal to the other. Refer to figure 3-4. Do not apply more than ±50 V from GUARD to LOW.

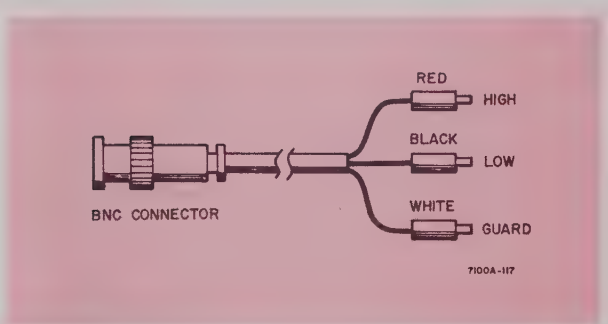


Figure 3-3 Test Cable

WARNING

DO NOT APPLY MORE THAN ±50 V BETWEEN GUARD AND LOW.

3-9. VOLTAGE MEASUREMENT - MANUAL RANGE SELECTION

WARNING

OUTSIDE SHELL OF VOLTS, OHMS, AND REAR-PANEL INPUT CONNECTORS ARE AT GUARD POTENTIAL. USE CAUTION IN MAKING MEASUREMENTS WHEN GUARD IS NOT AT GROUND POTENTIAL.

3-10. To measure dc voltages between 10 microvolts and 1100 volts, operate instrument as follows:

a. Connect instrument to ac power source. Push POWER switch.

b. Set Function/Range switch to 1000 volt range.

c. Connect test cable to VOLTS input connector.

d. Connect High, Low, and Guard pins on test cable to proper terminals on unknown voltage source.

e. Set SAMPLE RATE to MAX position.

f. Progressively select lower ranges until readout is between 16000 and 01599 or lowest range is reached.

NOTE

If OVR indicator in readout is lighted, input voltage is beyond range of instrument. Disconnect input cable from voltage source.

3-11. VOLTAGE MEASUREMENT - AUTOMATIC RANGING

3-12. To measure dc voltages with automatic ranging, use the following procedure:

a. Set Function/Range switch to VOLTS-AUTO position.

b. Connect input cable to unknown voltage source.

c. Set SAMPLE RATE control to position for desired sampling rate.

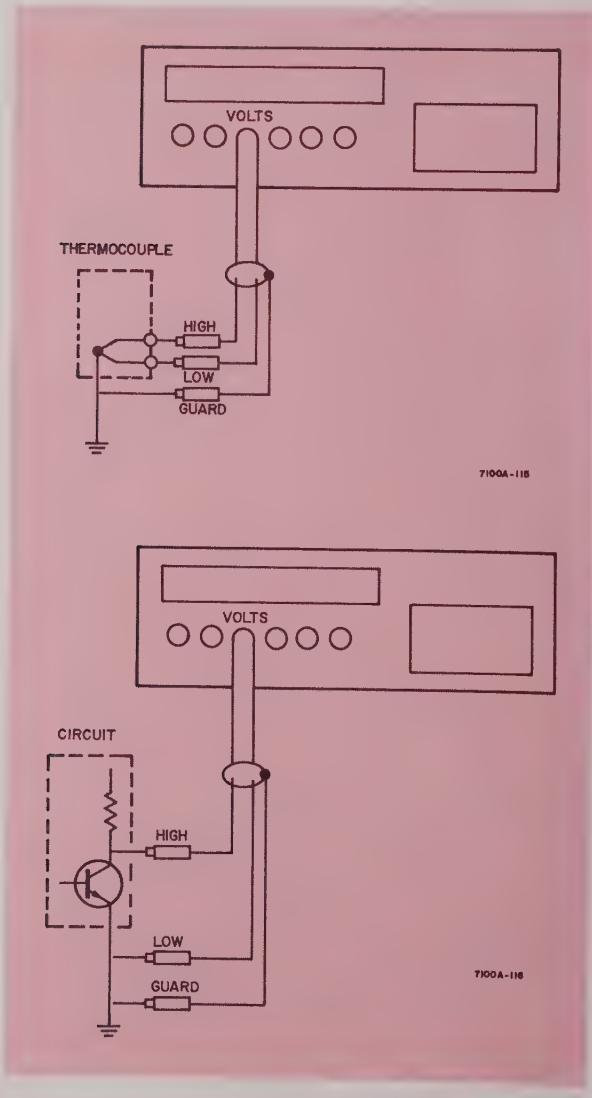


Figure 3-4 Guard Connections

d. Observe voltage measurement. If OVR indicator is lighted, disconnect input voltage.

3-13. VOLTAGE RATIO MEASUREMENT

3-14. To perform voltage ratio measurement proceed as follows:

a. Connect unknown voltage to VOLTS input connector. Connect low and guard to low side of input.

b. Connect external reference voltage to J6 on rear panel. Connect low and guard to low side of reference.

c. Set Function/Range switch to RATIO position.

d. Note readout. Reading is ratio of V_{in} to V_{ref} (E1/E2) with polarity automatically presented.

CAUTION

INPUT VOLTAGE MUST BE BETWEEN 1 MILLIVOLT AND 16 VOLTS; REFERENCE MUST BE BETWEEN +5 AND +16 VOLTS. REFERENCE VOLTAGE IN EXCESS OF 30 VOLTS WILL DAMAGE THE INSTRUMENT.

THE LOW SIDE OF EACH INPUT MUST BE AT THE SAME VOLTAGE WITH RESPECT TO GROUND OR COMMON. ANY VOLTAGE DIFFERENCE BETWEEN THE LOW SIDES WILL BE SHORTED BY THE GUARD.

3-15 RESISTANCE MEASUREMENT - MANUAL RANGE SELECTION

3-16. To measure resistance between 1 ohm and 16 megohms, use the following procedure:

a. Connect test cable to front panel OHMS connector.

b. Connect high and low cable terminals across unknown resistance.

c. Set Function/Range switch to range which gives the most accurate reading.

3-17. RESISTANCE MEASUREMENT– AUTOMATIC RANGING

3-18. To measure resistance in automatic ranging mode, proceed as follows:

a. Connect test cable to front panel OHMS connector.

b. Connect cable terminals across unknown resistance.

c. Set Function/Range switch to OHMS-AUTO position.

d. Adjust SAMPLING RATE control for desired rate of sampling.

3-19. OPTIONS 03 AND 04

3-20. Option 03 allows remote selection of function and range as well as remote triggering of the measurement cycle. Also included are data lines which give 1-2-2*-4 binary-coded decimal indication of the 5 readout digits, polarity, and decimal point placement. Function data is also given. Three output signals are provided which may be used in remote applications: a "sample complete" signal which indicates that the integration of the input signal is complete; a "print command" signal which shows that the entire measurement cycle is complete and data is available for external use; and a +20 volt reference for printer applications.

3-21. Option 04 is similar to Option 03 except that the outputs are coded in 1-2-4-8 BCD.

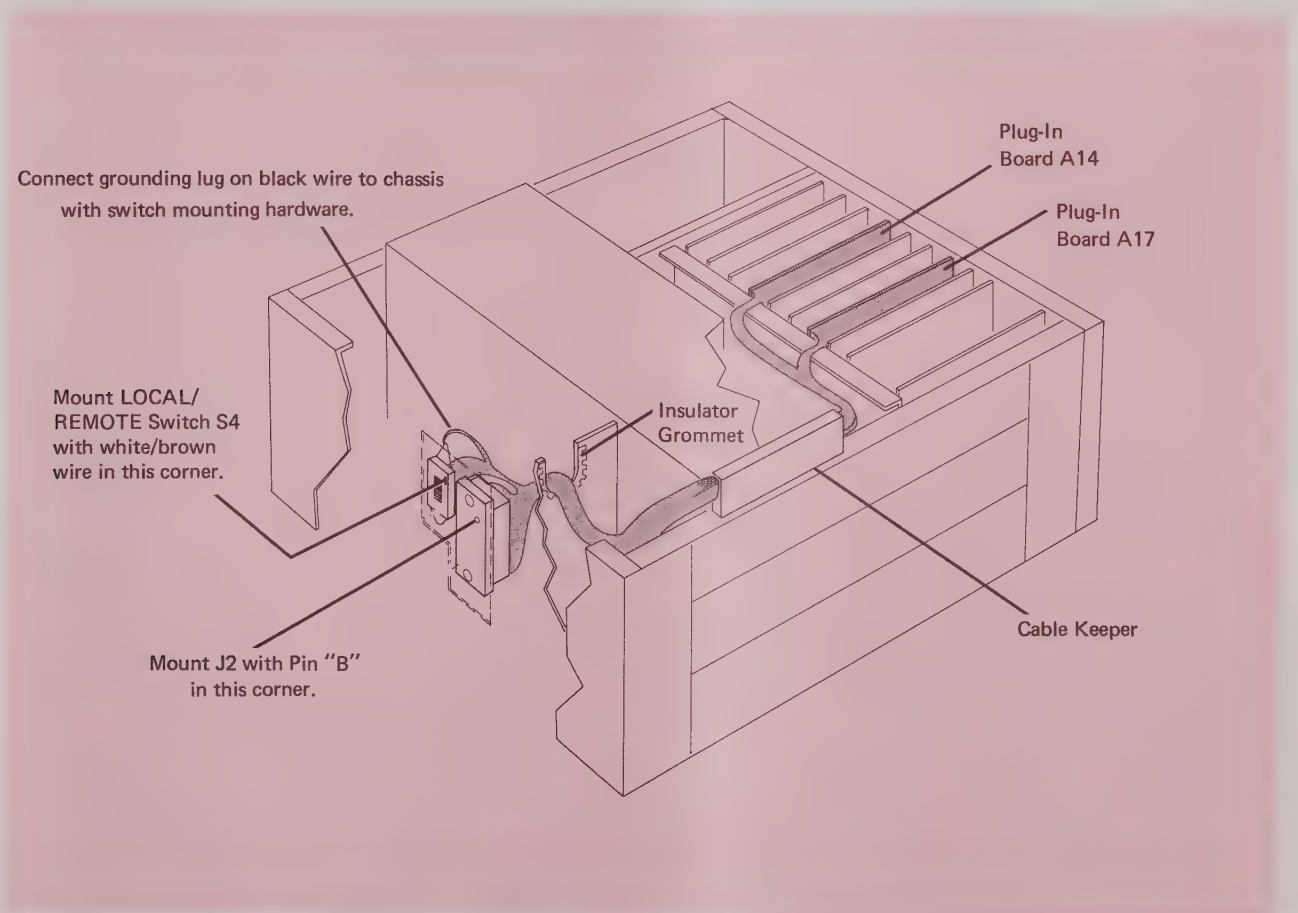

Connect grounding lug on black wire to chassis with switch mounting hardware.
Plug-In Board A14
Plug-In Board A17
Mount LOCAL/ REMOTE Switch S4 with white/brown wire in this corner.
Insulator Grommet
Cable Keeper
Mount J2 with Pin "B" in this corner.

Figure 3-5. Option 03/04 Installation Instructions

3-22. Installation Instructions

3-23. To install Option 03 or 04, perform the following steps:

a. Disconnect the Model 7100A from primary power source.

b. Remove top cover from Model 7100A.

c. Remove cover plate from printed circuit housing assembly on front left-hand area of instrument.

d. Remove rear panel backing plate covering areas marked "BCD OUTPUT and PROGRAMING (OPTIONAL)".

e. Insert board A14 into socket XA14 and board A17 into XA17. See figure 3-5.

f. Dress cable as shown, locating connector J2 and switch S4 at openings on rear panel. Check that both are correctly oriented.

g. Install cable keeper on wiring harness of option and attach to insulating board at edge of shielded enclosure.

h. Place insulator grommet on cutout in fan support bracket.

i. Attach connector J2 and switch S4 to rear panel with hardware supplied. Connect black ground wire to chassis.

j. Replace printed circuit enclosure cover and instrument top cover.

3-24. Output and Remote Programing Data

3-25. The data outputs supplied by Options 03 and 04 are fully detailed in table 3-1. The "0" state data level is approximately +0.5 V and the "1" state level is approximately +30 V. The source impedance is 20 kΩ. Remote programing information is listed in table 3-2. Programing connections can be made by contact closure to ground or with NPN transistor switches. Current required per contact closure is 100 mA, with +30 V across open contacts. Figure 3-6 shows the interconnect wiring between A14, A17, switch S4 and connector J2.

3-26. Remote Operation

3-27. The following instructions describe the various modes of remote operation that may be selected with Options 03 and 04.

3-28. Remote Function, Range and Start

a. Set LOCAL/REMOTE switch S4 to REMOTE.

b. Connect desired FUNCTION and RANGE lines on connector J2 to J2-pin W (chassis ground). See table 3-2.

c. Connect J2-Z to J2-Y.

d. Apply a +10 V to +30 V start pulse at J2- b . This will start a measurement cycle. Width of pulse must be $>.5$ msec and <10 msec. Rise time should not exceed 100 μsec.

e. At the end of measurement, a print command pulse ($\overline{\text{SDPC}}$) will appear at J2-CC.

3-29. Local Function and Range, Remote Start

a. Set LOCAL/REMOTE switch to REMOTE.

b. Select desired FUNCTION and RANGE with front panel Function/Range switch.

c. Connect J2-Z to J2-Y.

d. Connect J2-M to J2-W.

e. Apply a +10 V to +30 V pulse at J3- ⓑ . This will start a measurement cycle.

f. At the end of measurement, a print command pulse ($\overline{\text{SDPC}}$) will appear at J2-CC.

3-30. Remote Function and Range, Local Start

a. Set LOCAL/REMOTE switch to REMOTE.

b. Connect desired FUNCTION and RANGE lines on J2 to J2-W (chassis ground). See table 3-2.

c. Connect J2- ⓒ to J2- ⓑ .

d. Connect J2-X to J2- ⓐ . This enables front panel SAMPLING RATE control.

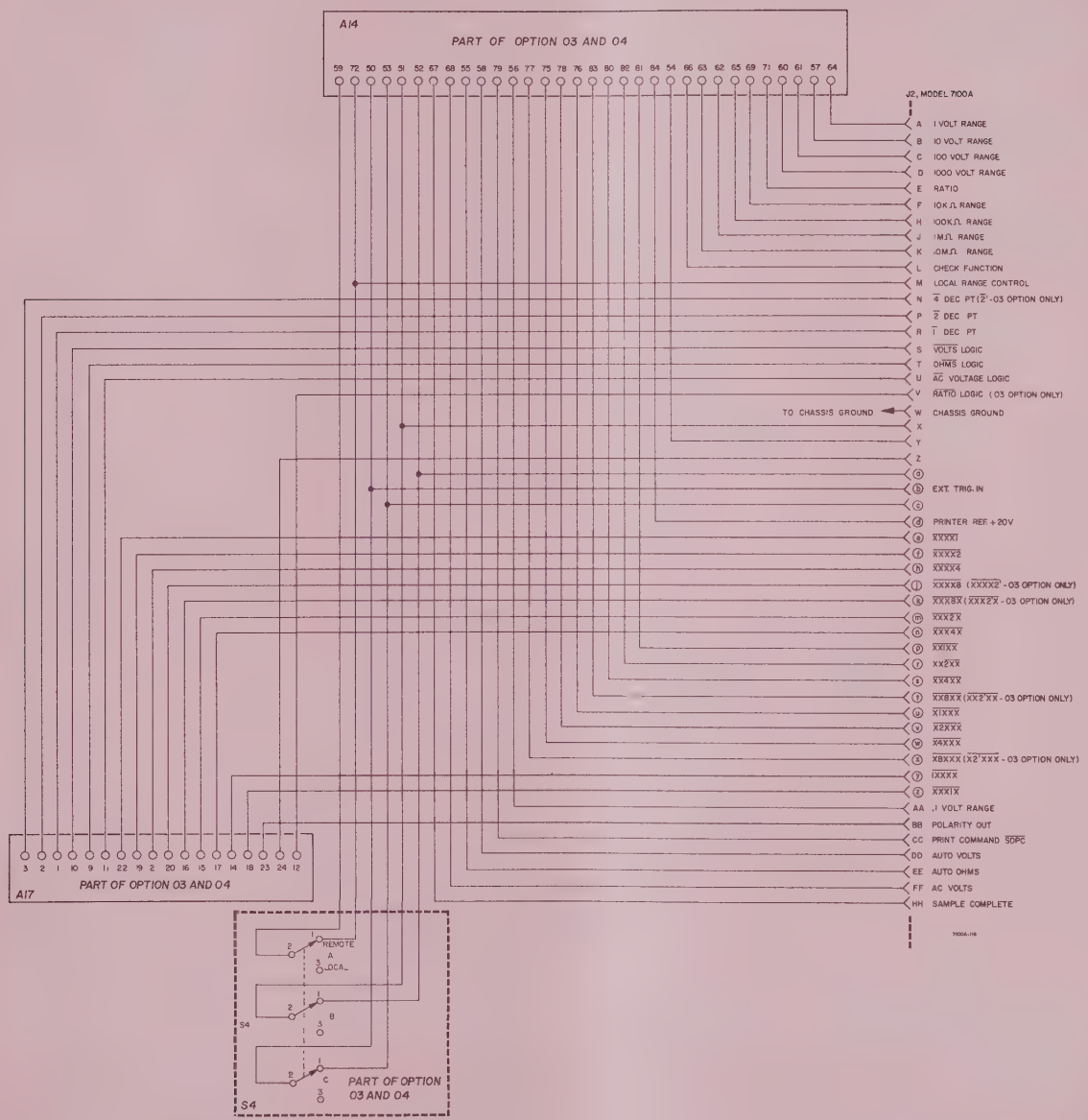


Figure 3-6. Option 03/04 Interconnect Wiring

Table 3-1. Option 03/04 Data Outputs

Output	Code		J2 Pin Designation	Remarks
	Option 03	Option 04		
10,000's	1	1	ⓨ	0 = 0 (+ .5 V) 1 = 1 (+30 V)
1,000's	1 2 4 2'	1 2 4 8	ⓤ ⓥ ⓦ ⓧ	122'4 Decoding: (OPTION 03) 4 2' 2 1 0 = 0 0 0 0 1 = 0 0 0 1 2 = 0 0 1 0 3 = 0 0 1 1 4 = 0 1 1 0 5 = 0 1 1 1 6 = 1 1 0 0 7 = 1 1 0 1 8 = 1 1 1 0 9 = 1 1 1 1 Digit Decoding xxxxx = 0 0 0 xxxx.x = 0 0 1 xxx.xx = 0 1 0 xx.xxx = 0 1 1 x.xxxx = 1 1 0 .xxxxx = 1 1 1 1248 Decoding: (OPTION 04) 8 4 2 1 0 = 0 0 0 0 1 = 0 0 0 1 2 = 0 0 1 0 3 = 0 0 1 1 4 = 0 1 0 0 5 = 0 1 0 1 6 = 0 1 1 0 7 = 0 1 1 1 8 = 1 0 0 0 9 = 1 0 0 1 Digit Decoding xxxxx = 0 0 0 xxxx.x = 0 0 1 xxx.xx = 0 1 0 xx.xxx = 0 1 1 x.xxxx = 1 0 0 .xxxxx = 1 0 1
100's	1 2 4 2'	1 2 4 8	ⓟ ⓡ ⓢ ⓣ	
10's	1 2 4 2'	1 2 4 8	ⓩ ⓜ ⓝ ⓚ	
Unit's	1 2 4 2'	1 2 4 8	ⓔ ⓕ ⓗ ⓙ	
Decimal Point	1 2 2'	1 2 4	R P N	
Function	VOLTS OHMS AC RATIO*		S T V U	FUNCTION selected = "1". All others = "0" * In option 04 only, all lines at "0" = RATIO, Pin V is not used.
Polarity			BB	Positive (+) = "0" Negative (-) = "1"
Print Command	$\overline{\text{SDPC}}$		CC	+30 volt pulse occurs when data is available for use.
+ Ref			ⓓ	Reference level +20 V 1.3 k source impedance.
Sample Complete			HH	+3.5 volt pulse occurs when integration of input voltage is complete.

Table 3-2. Option 03/04 Remote Programing Lines

Function		J2 Pin Designation	Remarks
VOLTS	AUTO	DD	Ground J2 pin for desired Function/Range switch position
	.1 V	AA	
	1 V	A	
	10 V	B	
	100 V	C	
	1000 V	D	
RATIO	1.0000: 1	E	
OHMS	AUTO	EE	
	10 K	F	
	100 K	H	
	1 M	J	
	10 M	K	
AC (DM-03A ONLY) VOLTS		FF	NOTE—Programs only AC indication on readout.
CHECK		L	
External Trigger In		ⓑ	+10 V to +30 V pulse or momentary short pin ⓑ to pin ⓒ .
CHASSIS GROUND		W	

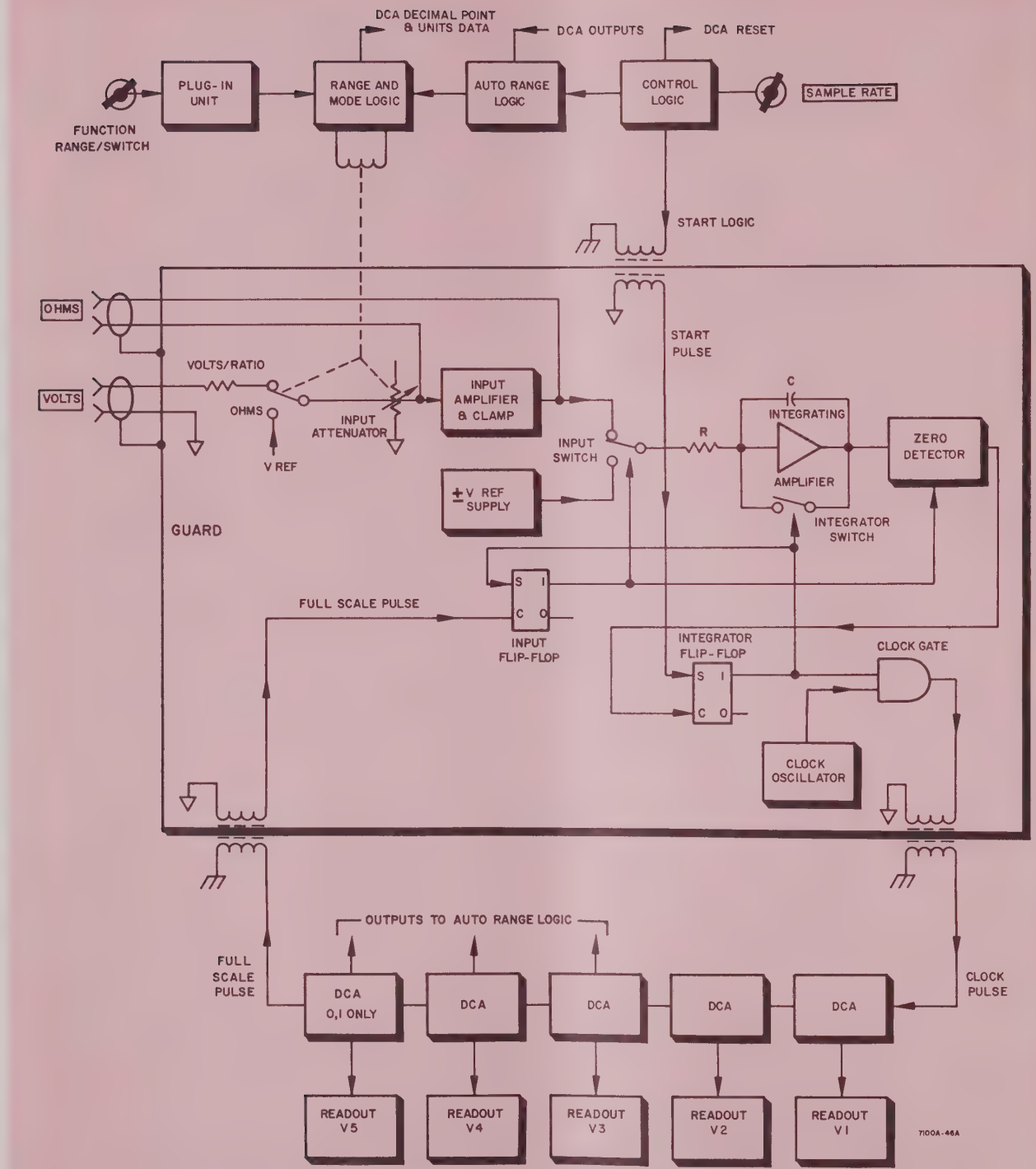


Figure 4-1. Overall Block Diagram

Section IV
Theory of Operation

4-1. INTRODUCTION

4-2. This section describes overall operational theory and details of individual circuits. Complete schematic diagrams of circuits discussed in this section are found in section V of this manual.

4-3. BASIC OPERATING PRINCIPLES

4-4. Figure 4-1 shows a simplified block diagram of the Model 7100A. In the following description assume that an unknown input voltage is connected to the VOLTS input connector and the function/range switch is set to the 10 volt range.

4-5. The unknown input signal is connected through mode switching relays to the input amplifier. On the 10 volt range, the input amplifier is connected as a voltage follower, with a gain of 1. At the beginning of a measurement cycle a start pulse is generated by the control logic. Referring to figure 4-2, the leading edge of the start pulse (time T_0) resets the counters to 10000. The trailing edge of the start pulse (time T_1) starts the measurement. The start pulse sets the integrator flip-flop which in turn sets the input flip-flop which connects the input switch to the input amplifier and disables the zero detector. The integrator flip-flop also opens the integrator switch and enables the clock gate. At T_1, the integrating amplifier starts integration of the input voltage and the counter starts accumulating clock pulses.

4-6. The counter accumulates clock pulses until reaching a count of 19999. The next pulse overflows the counter to 00000 and at time T_2 generates a pulse (called the full scale pulse) which resets the input flip-flop. The input flip-flop now connects the reference voltage to the integrator and enables the zero detector. The reference voltage is chosen by polarity logic (not shown in figure 4-1) to be opposite to the polarity of the input signal.

4-7. The integrator output goes to zero at a constant rate since the reference voltage is derived from a stable voltage source. When the zero detector indicates a zero crossing (time T_3) the integrator flip-flop is reset and the clock gate is closed. The readout now displays the number of clock pulses counted during the integration of the reference. The

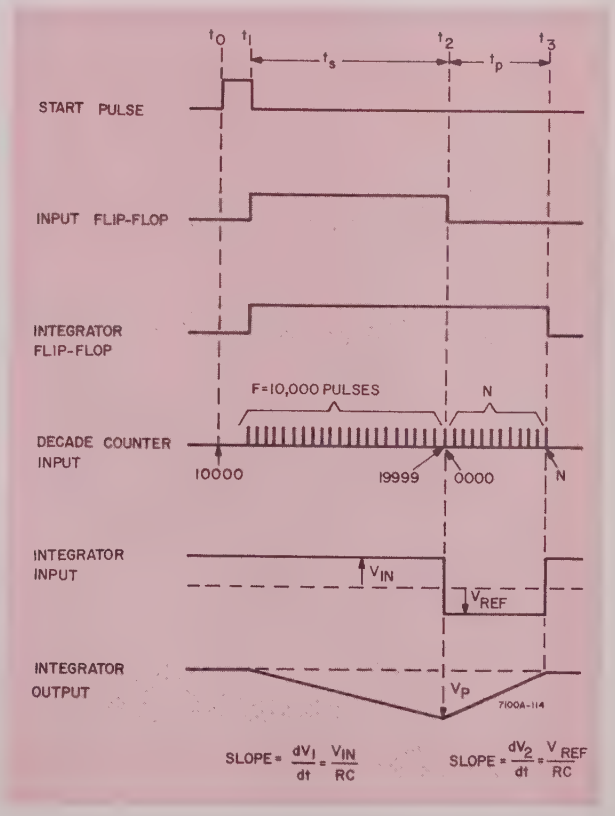


Figure 4-2. Timing Diagram

time required for the integrator to reach zero is directly proportional to the ratio of the input voltage to the reference voltage.

4-8. The reference voltage used to drive the integrator to zero is 10 volts and the output of the input amplifier may be as high as 16 volts. Therefore the integrator in this case cannot be driven back to zero in a period of 10000 counts. The counter for the most significant digit is allowed to overflow once during the integration of the reference and can thus indicate a count of 16000. This is equivalent to a 60% overrange of the normal full-scale value of 10000. If the output of the input amplifier exceeds 16 volts, a clamp circuit reduces the amplifier gain and lights a front-panel indicator to warn the operator that the measurement is off scale.

4-9. Resistance is measured by connecting the unknown resistance in the feedback circuit of the input amplifier. The reference voltage is connected to the input amplifier through precision resistors, the value depending on the range selected. The gain of the amplifier, and the output voltage, is determined by the value of the unknown resistance. Measurement of the amplifier output is the same as for voltage, and the readout is in kilohms.

4-10. Voltage ratios may also be measured with the same basic measurement circuit. In this case one of the two voltages is connected to the front-panel VOLTS connector and the other is connected to the external reference input jack on the rear panel. The input voltage at the front-panel connector is integrated for the first half of the cycle, but the external reference is integrated in place of the internal reference during the second half of the cycle.

4-11. LOGIC DESCRIPTION

4-12. Control and counter circuits in the Model 7100A use resistor-transistor NAND/NOR logic. This logic uses both conventional transistors and integrated circuit elements. The integrated circuits are of six different types manufactured by Fairchild Semiconductor: (See figures 4-3 and 4-4).

a. Type 910. This dual 2-input gate element is used in NAND/NOR functions. Each gate is independent from the other.

b. Type 911. This element is a single 4-input gate element used in NAND/NOR functions.

c. Type 914. This dual 2-input gate element is used in NAND functions in the counter assemblies.

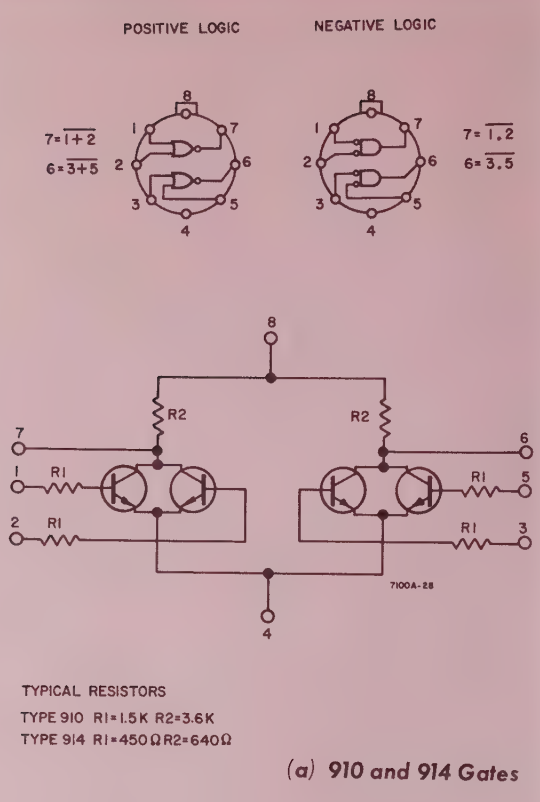
d. Type 915. This element is a dual 3-input gate used in NAND/NOR applications.

e. Type 923. This JK flip-flop is a complete storage element used in binary counter or gate control applications. The JK flip-flop differs from the ordinary RS flip-flop in that no ambiguous output state can occur from simultaneous "one" inputs. If "ones" are applied to both set and clear inputs, the output state will reverse.

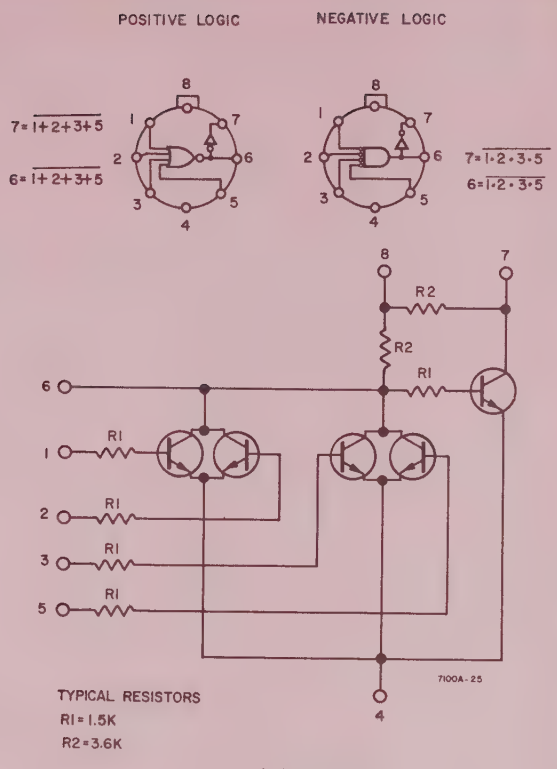
f. Type 927. This element contains 4 independent inverters.

4-13. RTL Basic Circuit

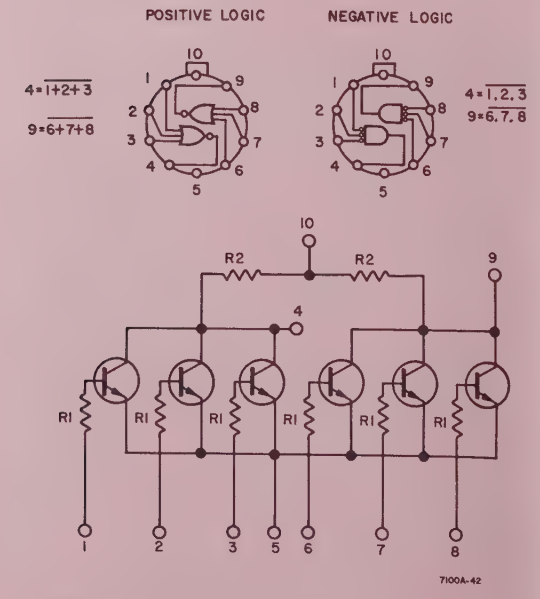
4-14. The basic RTL (resistor-transistor logic) circuit is shown in figure 4-5(a). The circuit consists of a transistor, a base resistor (R_B), and a collector load resistor (R_C). Approximate values for R_B and R_C are 450 ohms and 640 ohms respectively. In operation, the circuit acts as a switch, the output changing from a high (off) voltage level to a low (on) voltage level. In the off condition, the output level is approximately the V_{cc} value (+3.6 volts); in the on condition, the level is V_{SAT} (0.2 to 0.3 volts). An input level of approximately 0.75 volts will hold the output high; and input of 0.85 to 1.5 volts will hold the output low. If additional base resistors are added to the circuit, (see figure 4-5(b), the circuit then may



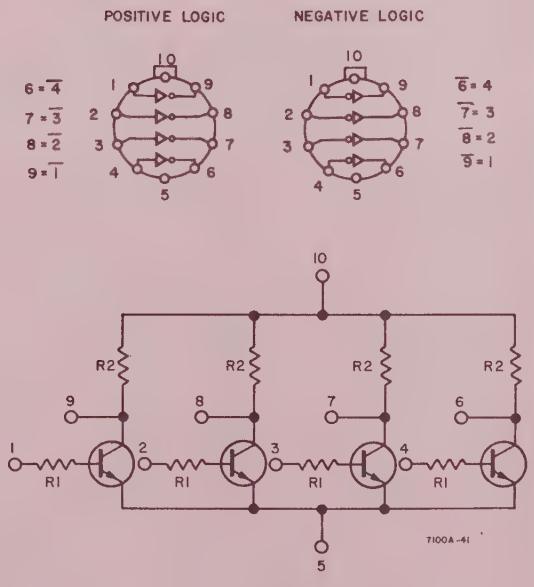
(a) 910 and 914 Gates



(b) 911 Gate



(c) 915 Gate



(d) 927 Inverter

Figure 4-3 Integrated Circuit Gate Elements

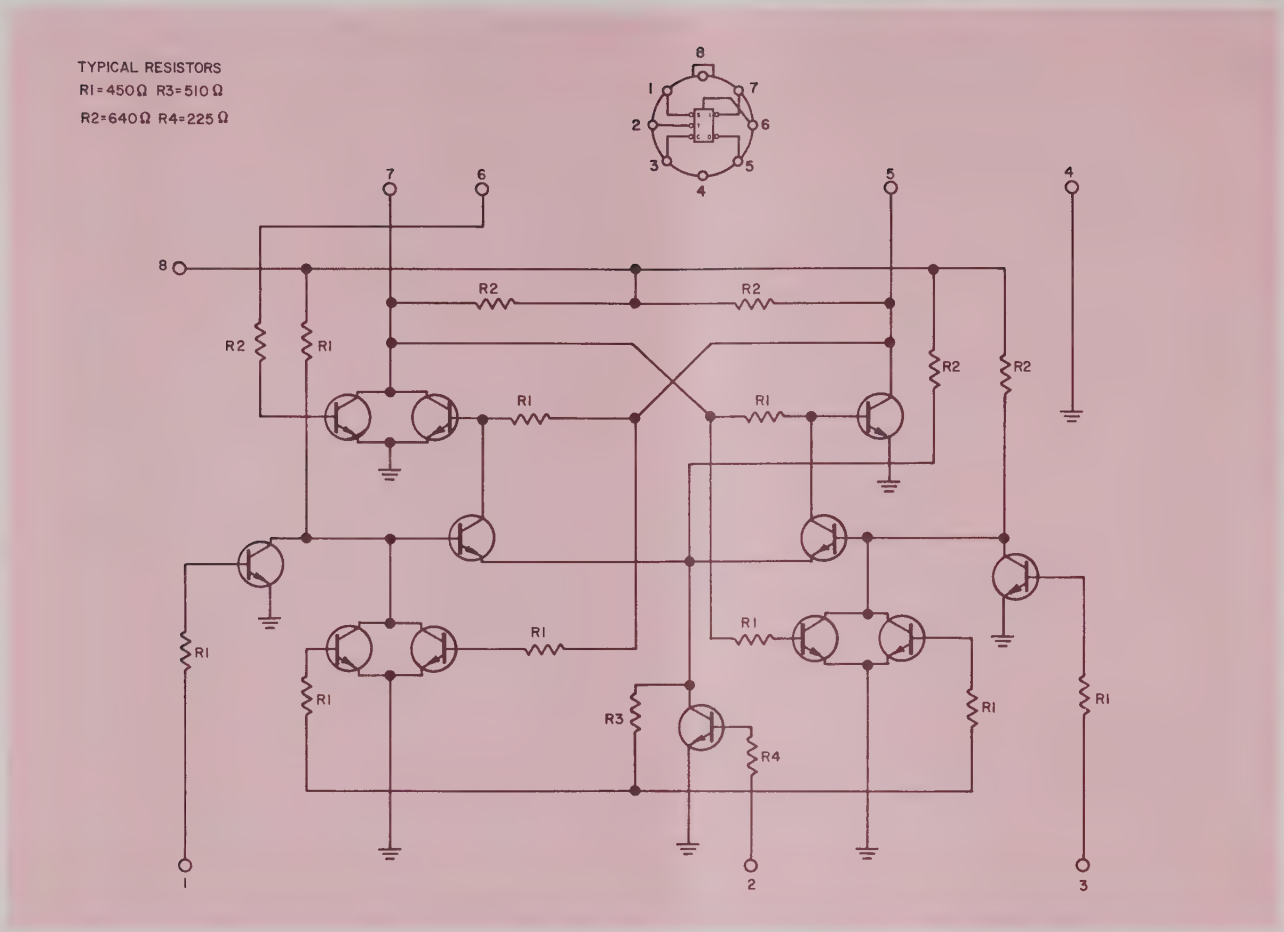


Figure 4-4. Type 923 J-K Flip-Flop Element

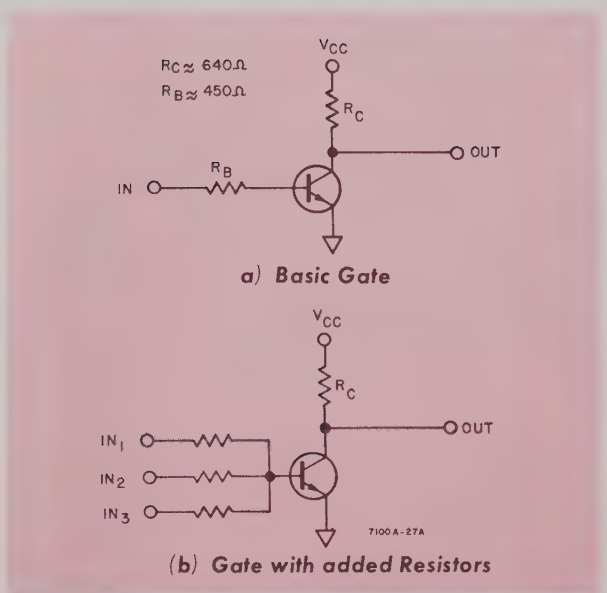


Figure 4-5. Basic RTL Logic

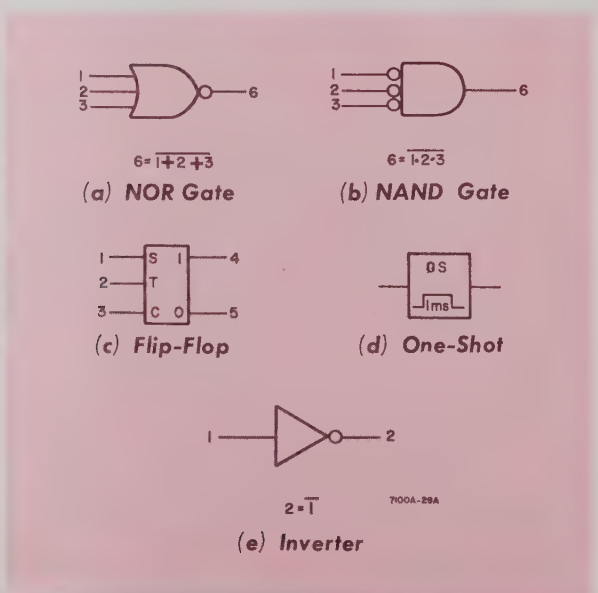


Figure 4-6. Logic Symbols

be used in the NAND/NOR function. For example, if any input is high, the output will be low. In the opposite situation, all inputs must be low for the output to be high.

4-15. Logic Symbols

4-16. The symbols used in this section designate the function of the gate. These symbols, shown in figure 4-6, are based on MIL-STD-806B. The NOR function is shown in figure 4-6(a). If any one of the inputs is high, the output is low. The circle at the output of the symbol indicates that the activated state is relatively low. The NAND function is shown in figure 4-6(b). All of the inputs must be low for the output to be high. The circles at the input connections indicate that relatively low input levels activate the function. Other symbols used are shown in figure 4-6(c, d, e). The flip-flop uses the following conventions:

a. The "1" output is activated when an active signal appears at the "S" (set) input.

b. The "0" output is activated when an active signal appears at the "C" (clear) input.

c. The flip-flop will change states when a signal is applied to the "T" (toggle) input.

The one-shot or single-shot is shown by a block with "SS" designation. The output provides a pulse each time the input is activated. The width of the pulse may be designated within the block. Amplifiers (buffers or inverters) are shown by the triangular symbol. In the case of inverters, a circle at the input designates that a relatively low input activates the function. A circle at the output designates that the activated function is relatively low.

4-17. INPUT CIRCUITS

4-18. Figure 4-7 shows the input attenuator and input amplifier circuits. The circuits are arranged to control attenuation of input signal and amplifier gain in dc measurement and ratio, and modify amplifier configuration in resistance measurement.

4-19. DC Voltage Measurement

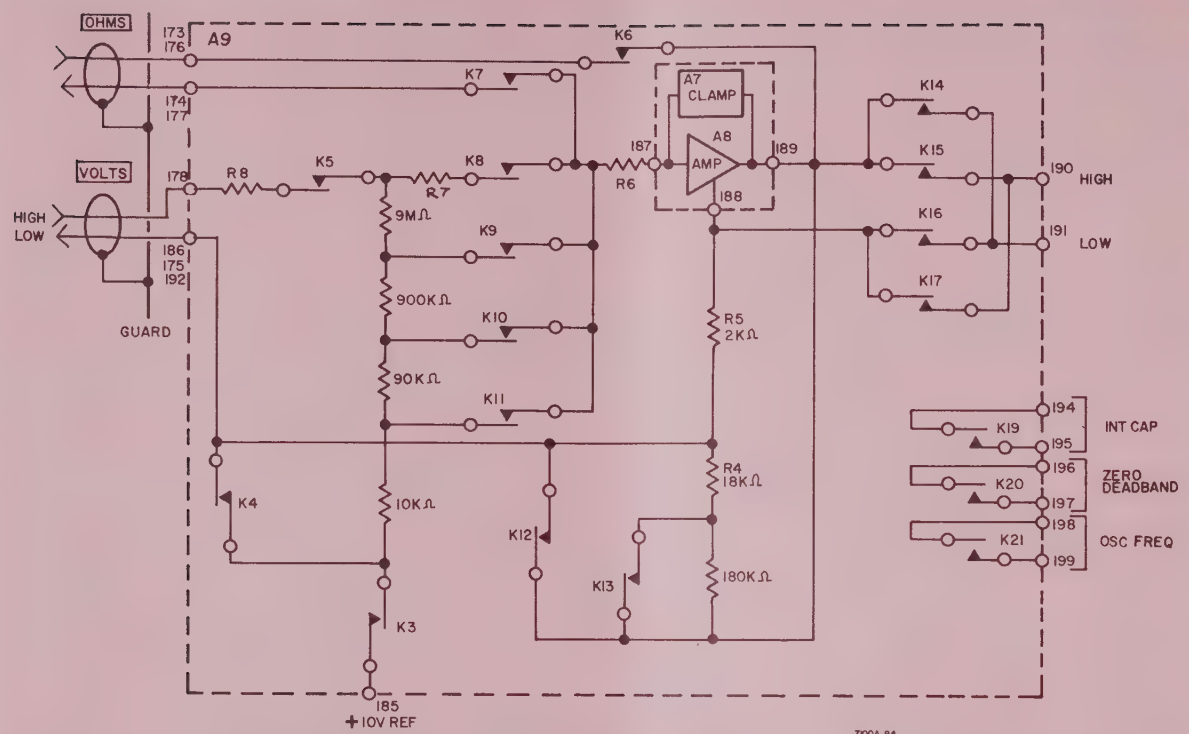
4-20. In measurement of dc voltages, voltage ratios, and in check mode, the signal is amplified or attenuated to an equivalent voltage on the 10 volt range. For example, on the .10 volt range, signals are amplified by 100; on the 1000 volt range, signals are attenuated by 100. Referring to figure 4-7, the input attenuator consists of 4 precision resistors arranged as a voltage divider with division ratios of 1/10 and 1/100. The output of the attenuator goes to amplifier A8 which, depending on the range selected, operates as a voltage follower with a gain of +1 or as a voltage amplifier with gains of +10 or +100. The gain of the amplifier is controlled by the 180 kΩ, 18 kΩ, and 2 kΩ resistors connected from the amplifier output to the common terminal. On the .1 volt range, relays A9K12 and A9K13 are open, and the amplifier gain is 100, determined by the ratio of 200 kΩ to 2 kΩ. On the 1 volt range, A9K13 is energized, shorting out the 180 kΩ resistor and making the amplifier gain 10. On the 10 volt and higher ranges A9K12 is energized, shorting out both 180 kΩ and 18 kΩ resistors, making the gain unity.

4-21. Voltage Ratio Measurement

4-22. In voltage ratio measurement, the attenuator and amplifier connections are identical with those of the 10 volt dc range. The input signal is not attenuated and the amplifier is connected for a gain of +1. A relay on range assembly A9 (not shown in figure 4-7) connects the external reference input to the integrating amplifier input switch matrix.

4-23. Resistance Measurement

4-24. The input configuration for resistance measurement is shown in figure 4-8. In this mode, the input amplifier is connected as a voltage amplifier



RANGE	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17
.1			X			X						X			X
1			X			X					X	X			X
10			X			X				X		X			X
100		X	X				X			X		X			X
1000		X	X					X		X		X			X
RATIO			X			X				X		X			X
10K	X			X	X				X				X	X	
100K	X			X	X			X					X	X	
1M	X			X	X		X						X	X	
10M	X			X	X	X							X	X	
CHECK	X							X		X		X			X

X RELAY CLOSED RELAY OPEN

Figure 4-7. Input Circuit

with gain determined by the ratio of the feedback resistance (unknown resistance R_X) to the input resistance. The input to the amplifier is the +10 volt reference, and the input resistance is the set of precision resistors used in the input attenuator. Referring to figure 4-7, on the 10 kΩ range the +10 volt reference is connected by relay A9K3 to a 10 kΩ precision resistor which in turn is connected to the amplifier summing point by relay A9K11. If the unknown resistance is exactly 10 kΩ, for example, the gain of the amplifier is unity and the readout is 10.000. On the 100 kΩ range, A9K10 is closed, making the resistance 100 kΩ (10 kΩ plus 90 kΩ).

The 1 and 10 megohm ranges close relays A9K9 and A9K8 to make the input resistance 1 MΩ and 10 MΩ respectively. On each range the gain of the amplifier

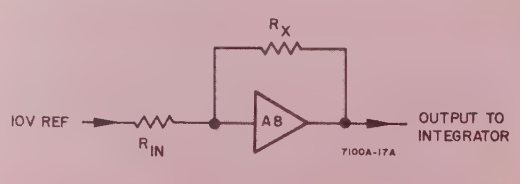


Figure 4-8. Resistance Measurement

can be as high as 1.6 since the integrator circuits have a 60% overrange capability.

4-25. Input Amplifier

4-26. Input amplifier A8 is similar to the Fairchild Type A00-10 chopper-stabilized operational amplifier. The circuit, shown in figure 4-9, consists of ac differential amplifier and a dc carrier amplifier. Frequencies above 5 Hz are coupled directly into one input of the differential amplifier. Frequencies from dc to 5 Hz are chopped by photoconductors driven by a free-running multivibrator. The resultant ac signal is amplified by a high gain carrier amplifier. The output of the carrier amplifier is demodulated by a transistor switch which is also driven by the multivibrator. The demodulated signal passes through an RC filter which removes any remnants of the carrier frequency. The amplifier dc signal is then applied to the second input of the differential amplifier.

4-27. Clamp And Overload Circuit

4-28. The input amplifier is shunted by a clamp circuit which limits its output to ±16 volts, approximately. The clamp prevents the input amplifier from saturating, providing quick recovery from overloads. With signal voltages at normal levels, the clamp is turned off and is effectively a very high resistance. When the clamp limits are exceeded, the circuit becomes a low resistance, effectively shorting the amplifier. In addition, an overload circuit detects the clamp action and lights a front-panel indicator to warn the operator that an overload exists.

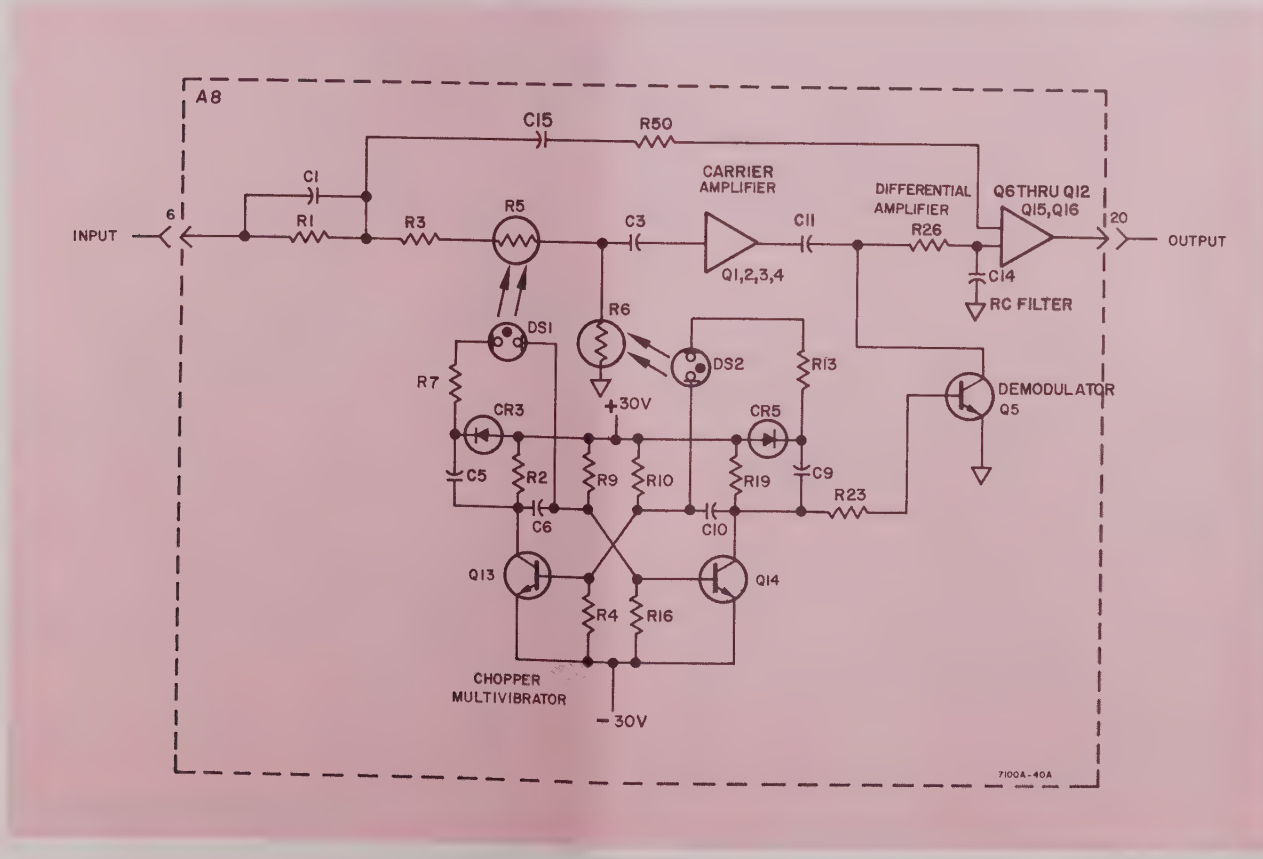


Figure 4-9. Input Amplifier

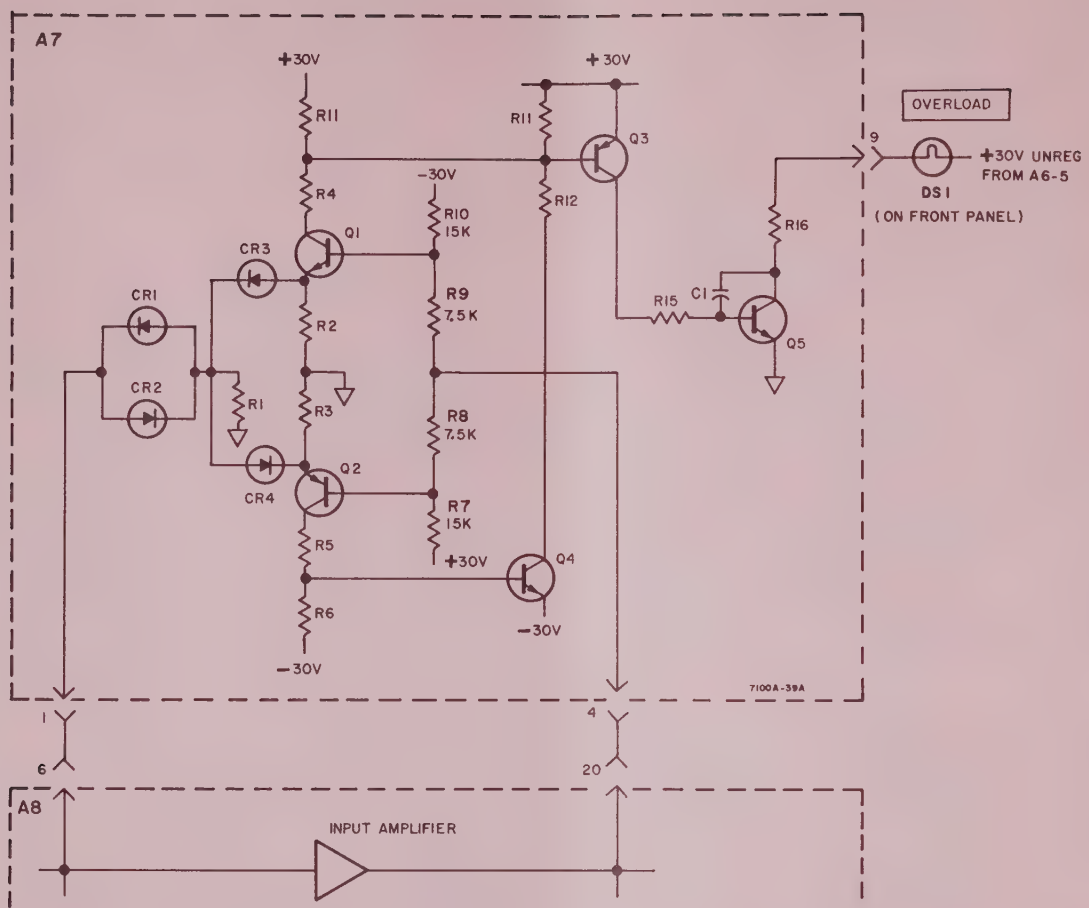


Figure 4-10. Clamp and Overload Circuit

4-29. Referring to figure 4-10, when the amplifier output is zero, A7Q1 and A7Q2 are cut off by a dc bias of approximately -10 and +10 volts respectively. the amplifier output increases, reverse bias is decreased on one transistor and increased on the other. When the amplifier output reaches approximately 16.15 volts, one of the transistors will be at a zero bias point, and any further increase in output will cause the stage to conduct. For example, if the amplifier output goes positive, the bias on A7Q1 becomes more positive. If the amplifier output exceeds 16.15 volts, A7Q1 conducts and the output is clamped by A7CR1 and A7CR3. If the amplifier exceeds the limit in the negative direction, A7Q2 conducts and the output is clamped by A7CR2 and A7CR4. The overload lamp is controlled by level detectors A7Q3 and A7CR4, and lamp driver A7Q5. When A7Q1 conducts, the level at the base of A7Q3 goes negative, turning on A7Q3 and saturating A7Q5. When A7Q2 conducts because of an overload in the negative direction, the level at the base of A7Q3 also goes negative and the lamp is lighted.

4-30. INTEGRATOR CIRCUITS

4-31. The integrator circuits consist of the integrator input switch, integrating amplifier, integrator switch, and zero detector. These circuits convert

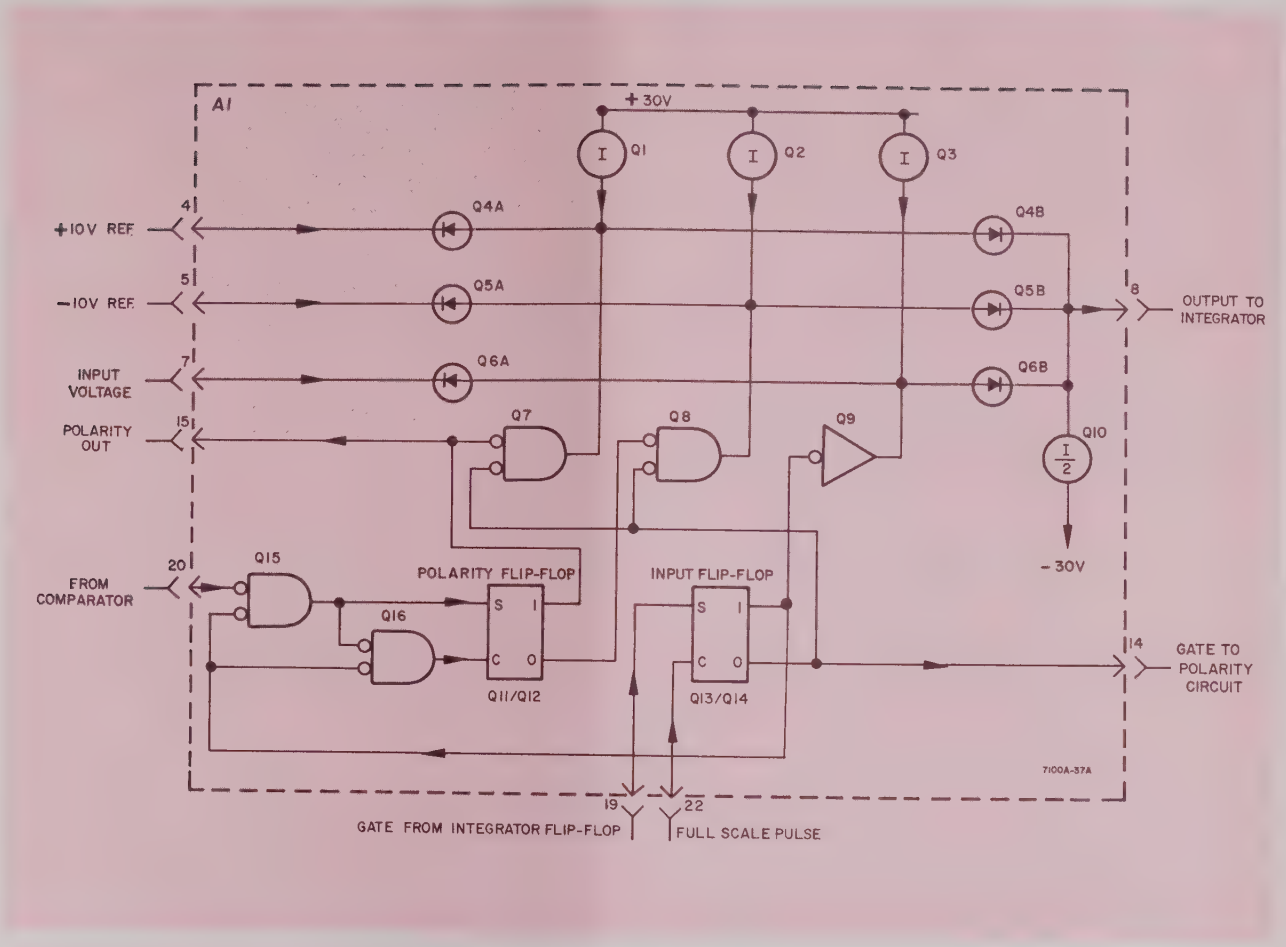


Figure 4-11. Integrator Input Switch

the analog input and reference voltages to time-related control signals for the digital portion of the instrument.

4-32. Integrator Input Switch

4-33. Integrator input switch A1 is shown in simplified form in figure 4-11. The switch circuit is a 1 x 3 matrix which connects the integrating amplifier to either the input signal, the -10 volt reference, or the +10 volt reference. The operation of the switch is controlled by driver gates A1Q7, A1Q8, and A1Q9. The gates are in turn controlled by the input and polarity flip-flops. Gates A1Q7 and A1Q8 controlling the reference inputs are 2-input AND gates. During the period when the input voltage is integrated, the "0" output of the input flip-flop holds the gates on and the reference lines open. When the full scale pulse resets the input flip-flop, the inhibiting voltage is removed and one of the gates is enabled by the polarity flip-flop. The state of the polarity flip-flop is determined by the output of the comparator circuit. Current sources A1Q1, A1Q2, and A1Q3 supply current into the switching diodes. Only one source supplies current at any one time since only one of the gates is off at that time. A1Q10 is a current sink and absorbs half of the current supplies by A1Q1-A1Q3. The remaining current is absorbed by one of the voltage sources.

4-34. Integrator

4-35. Integrating amplifier A2, shown in figure 4-12, is an operational amplifier with capacitive

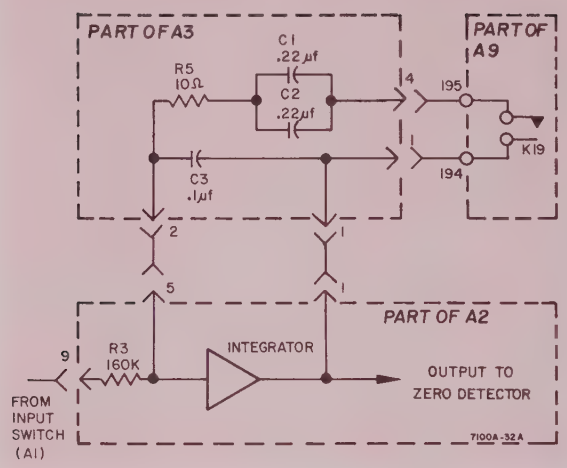


Figure 4-12. Integrator Simplified Diagram

feedback. According to the restrictions placed on an operational amplifier, the summing point must be at ground potential but must conduct no current to ground. Any current through the feedback loop charges the capacitor and is stored as a voltage from the output to ground. If a voltage step is applied to the amplifier input, the output rises at a constant rate determined by the time constant RC. The final level of the amplifier output is given by:

$$V_{out} = \frac{-1}{RC} \int_{t_0}^{t_1} V_{in}\, dt$$

where t_0 and t_1 are the beginning and end points of the measurement cycle. If sinusoidal components

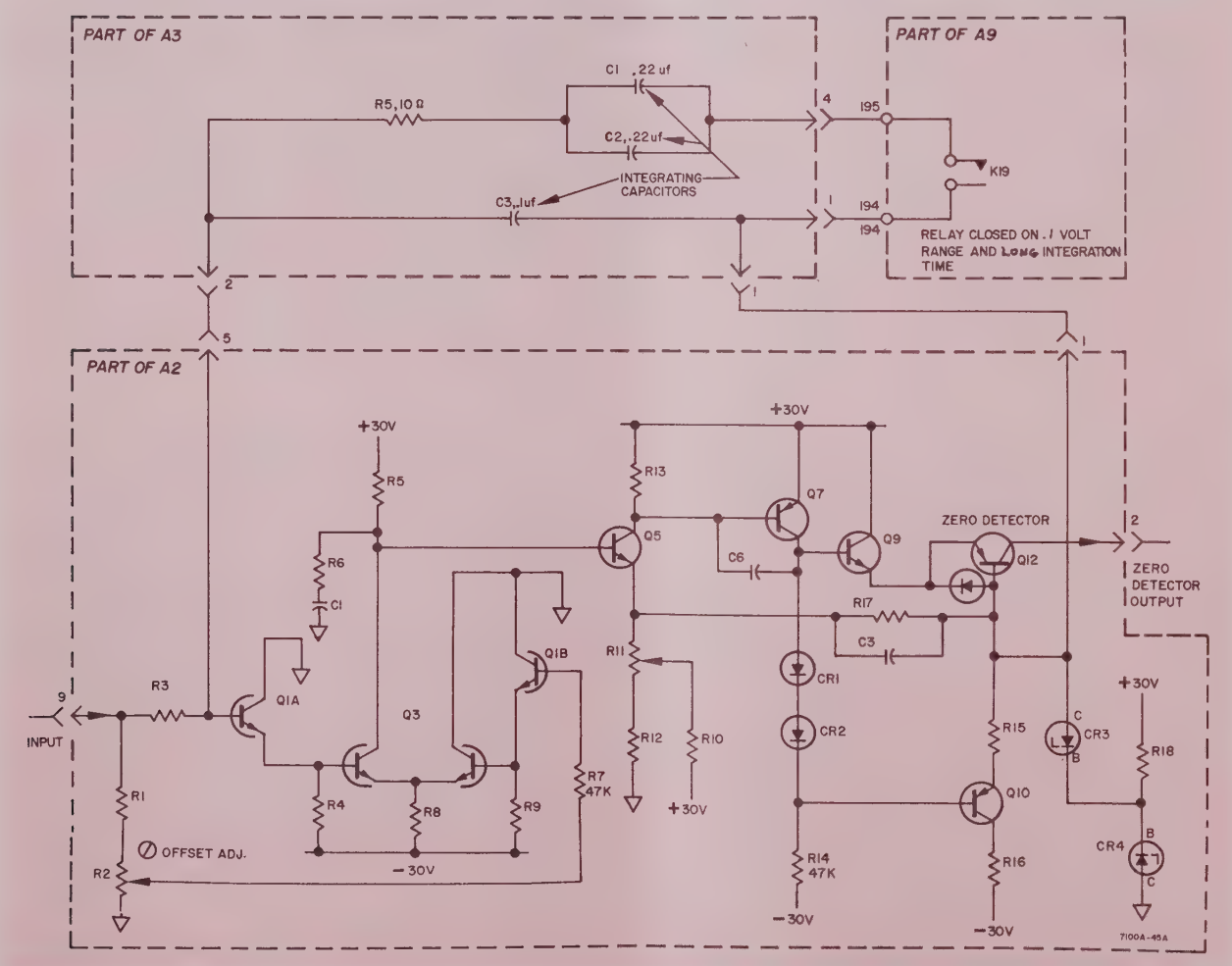


Figure 4-13. Integrator Schematic Diagram

are present in the input voltage, their integral is zero, and the final output of the integrator is not affected, provided the integration time is an integral multiple of the period of the input sine wave.

4-36. A complete schematic of the amplifier is shown in figure 4-13. The input stages are direct-coupled differential amplifiers, with a single-ended output to amplifier stage A2Q5. Amplifier A2Q5 in turn drives A2Q7, which provides two outputs; one to drive the zero detector circuit and one to drive output complementary emitter followers A2Q9 and A2Q10. The output is fed back to the summing point (base of A2Q1A) through capacitors mounted on circuit board A3. Normal integrating capacitance is 0.1 μf (A3C3), but on the .1 volt range 0.44 μf is switched in parallel with A3C3 to increase integration time.

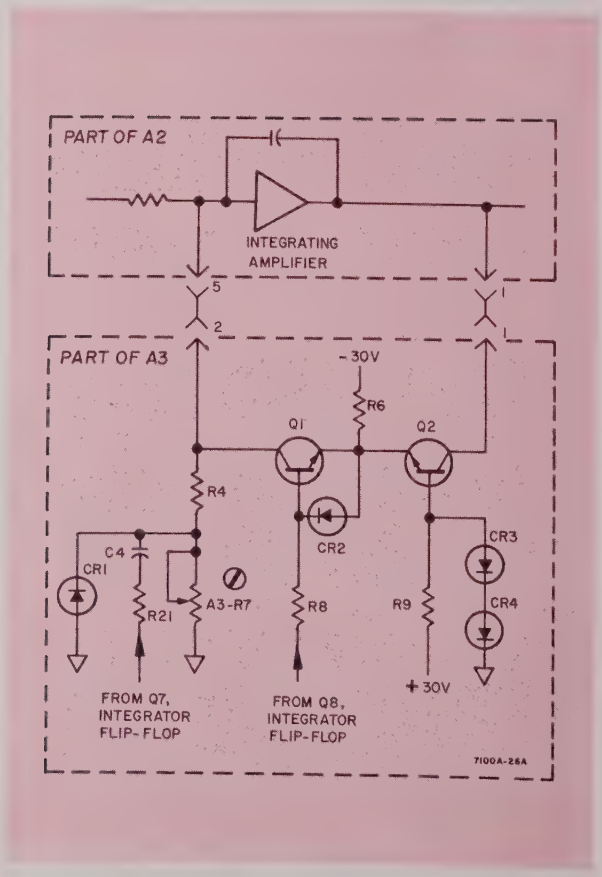


Figure 4-14. Integrator Switch

4-37. Integrator Switch

4-38. Integrator switch A3 is shown in simplified form in figure 4-14 and a full schematic is shown in figure 5-18. The switch consists of A3Q1 and A3Q2 operated to provide an extremely low offset voltage when the switch is on and low leakage when off. The switch is driven by the positive-going signal at the collector of A3Q8 in the integrator flip-flop. The switch is opened when the measurement cycle starts and closed when it ends. An additional input from A3Q7 in the integrator flip-flop counteracts the capacitive characteristic of A3Q1.

4-39. Zero Detector Logic

4-40. The basic circuit for the zero detector logic is shown in figure 4-15. The logic is required to change the bipolar output of the zero detector to a unipolar signal to reset the integrator flip-flop. For a positive input voltage the zero detector output is high and goes low at zero; for a negative input the detector output is low and goes high. The circuit consists of inverter A3Q3 and gates A3Q4, A3Q5, and A3CR5/A3CR6. The output of the zero detector is coupled to the input of A3Q3. The output of A3Q3 is an inversion of the input signal. At zero crossover, a negative input voltage produces a low signal and a positive input signal produces a high signal. For example, if the input voltage at crossover is negative, the output of A3Q3 is positive. The positive input of A3Q3 disables that gate, but A3Q5 is enabled and resets the integrator flip-flop. Conversely, if the output of A3Q4 is negative, A3Q5 is disabled and A3Q4 is enabled, resetting the flip-flop. To prevent an output from either gate at the beginning of the measurement cycle, both gates are disabled by the input flip-flop. An output from the integrator flip-flop is used to gate the clock on at the beginning of the cycle and gate if off when zero crossover is detected.

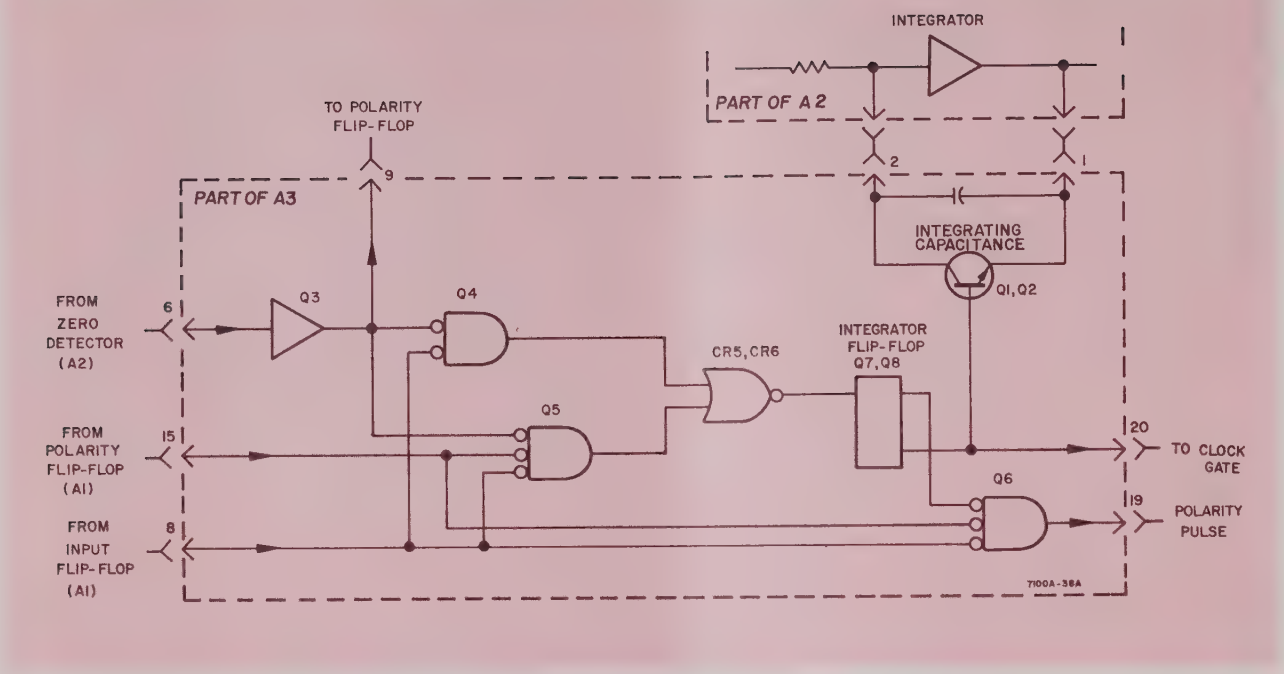


Figure 4-15. Zero Detector and Polarity Logic

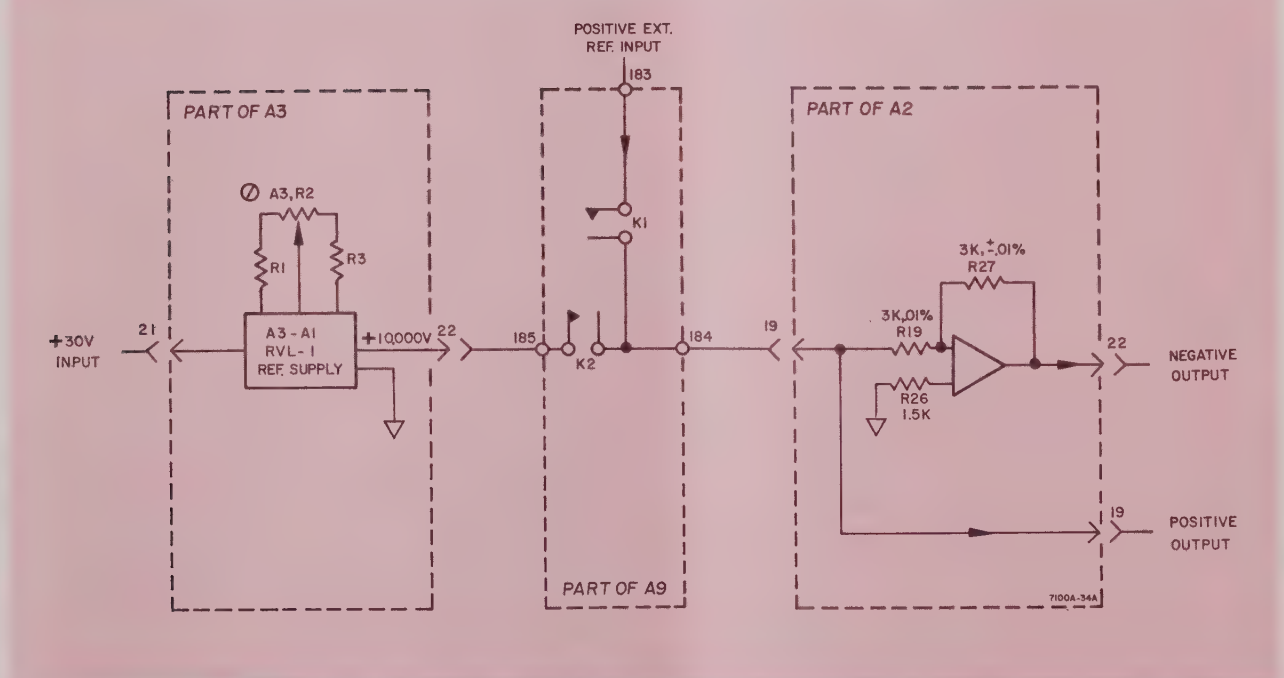


Figure 4-16. Reference and Inverter

4-41. REFERENCE AND INVERTER

4-42. The internal reference voltages are generated by a precision reference supply and a stable inverting amplifier. Referring to figure 4-16, the primary reference is the +10.000 volt output of a Fairchild Type RVL-1 voltage reference. The unit is a sealed supply mounted on circuit board A3.

4-43. The output of the +10 volt reference is inverted by an amplifier circuit on circuit board A2. Figure 5-14 shows the complete schematic. The circuit is very similar to the integrating amplifier described in paragraph 4-34. As may be seen by comparison with the integrator circuit, the two are identical up to the output stage. The reference inverter is connected as a voltage amplifier with a gain of one. Relay circuits on circuit board A9 allow connection of an external reference in voltage ratio measurements. The external reference is also inverted to allow measurement of positive and negative ratios.

4-44. CLOCK CIRCUIT

4-45. The clock, shown in figure 4-17, consists of a crystal-controlled oscillator, ring counter frequency divider, and gating circuits. The crystal-controlled oscillator operates at a frequency of 600 kHz (500 kHz with Option 02). The output of the oscillator drives a ring counter which divides the frequency by five. Gate circuits select either 600 kHz or 120 kHz, depending on the range and integration time selected. If fast integration time is selected, relay A9K21 closes and the gate for the 600 kHz output of the oscillator is enabled. The same relay disables the gate for the 120 kHz output. If slow integration time is selected

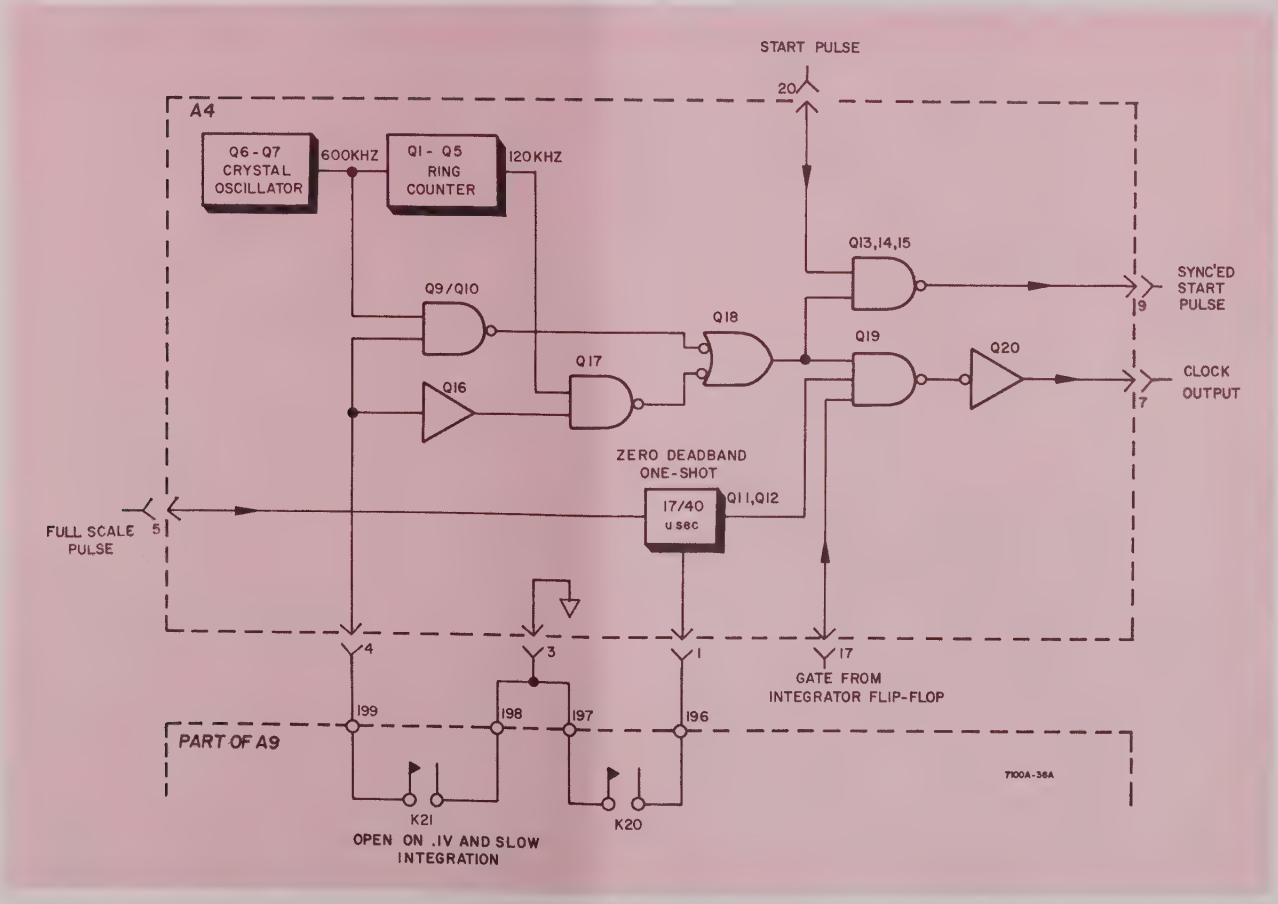


Figure 4-17. Clock Circuit

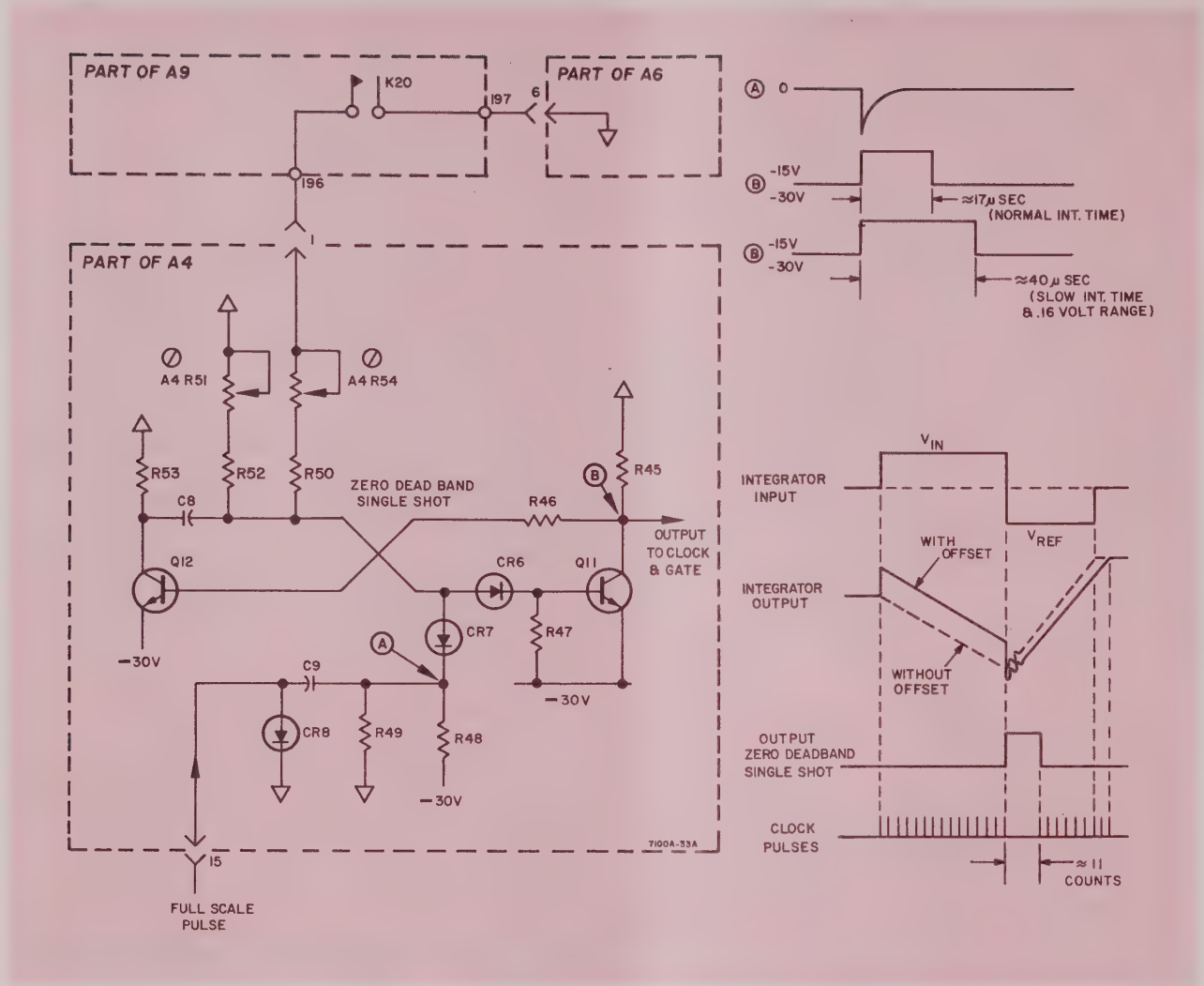


Figure 4-18. Zero Deadband One-Shot

or if the .1 volt range is selected, relay A9K21 is open and the 600 kHz gate is disabled. Both frequencies go to the input of a NOR gate whose output goes to one input of a NAND gate. The other two inputs to the NAND gate are from the zero deadband one-shot and the gate signal from the integrator flip-flop. The integrator flip-flop enables the clock gate at the beginning of the integration period and disables the gate at the time a zero crossover is detected. The gate is also disabled for a short period by the zero deadband one-shot at the time the integrator input switch is switching from the input signal to the reference.

4-46. ZERO DEADBAND ONE-SHOT

4-47. The circuit for the zero deadband one-shot is shown in figure 4-18. This one-shot compensates for possible errors from spurious responses in the output of the integrator caused by the integrator input switch circuit. These responses are liable to cause errors, especially at low input signal levels, from false zero crossover detection. To prevent errors, an offset voltage derived from the input signal is introduced into the integrator to move the switching point further from zero. This effectively makes the integrator output higher than the actual signal level.

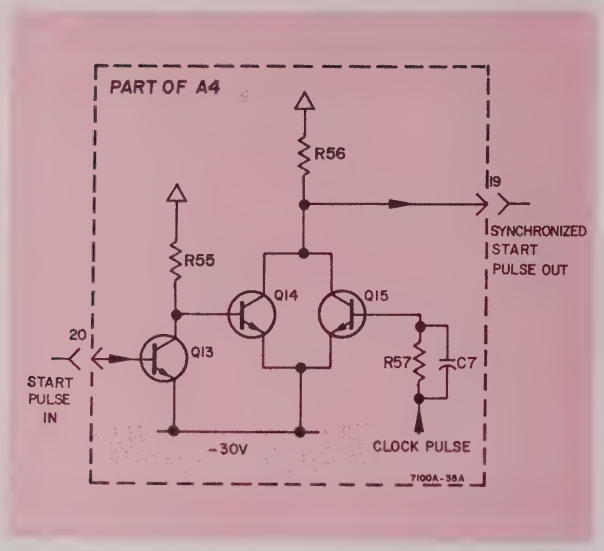


Figure 4-19. Synchonized Start Circuit

The zero deadband one-shot inhibits the accumulation of clock pulses in the counter to compensate for the offset voltage. This amounts to approximately 11 counts.

4-48. SYNCHRONIZED START CIRCUIT

4-49. A simplified schematic of the synchronized start circuit is shown in figure 4-19. The purpose of this circuit is to provide a start signal for the measurement circuits which is synchronized with the clock frequency. The circuit operates as follows: clock pulses appear continuously at the base of A4Q15. Start pulses from the cycle control circuits are applied to the base of A4Q13. Prior to a start pulse, the level at the base of A4Q13 is low and A4Q13 is turned off. A4Q14 is saturated, and clamps the collector of A4Q15. When the start pulse turns on A4Q13, A4Q14 turns off, releasing the collector of A4Q15. When the next negative-going transition of the clock pulse occurs, A4Q15 turns off and the output at the collector goes high. The next positive transition turns A4Q15 on and the output goes low. This negative-going portion of the waveform triggers the integrator flip-flop and starts the measurement cycle.

4-50. Control Logic

4-51. The analog and analog-to-digital portions of the instrument are mounted in a guard shield isolated from the chassis. All signals into and out of the guarded circuits (except for voltage and resistance inputs) are coupled by pulse transformers which are shielded electrostatically. The control logic determines the recycling rate of the measurement circuits and, in autoranging mode, controls the upward or downward change of range. Also included in the circuits located outside the guard are the decimal counters and display circuits. These will be discussed in later paragraphs.

4-52. The major portion of the control logic is shown in figure 4-20. These circuits control the sampling rate and display of the measurement result. In the following description assume that manual range selection is used.

4-53. CYCLE CONTROL

4-54. The measurement cycle begins when the start/reset one-shot resets the decimal counters and sends a start pulse to the integrator. As described previously, integration of the input signal begins and clock pulses begin to be accumulated in the decimal counters. When a zero crossover is detected, the clock is gated off. The "count complete" circuit detects that the clock pulses have stopped, and generates a pulse designated CCP. This pulse performs three functions: it triggers the sample rate one-shot, generates print command pulse SDPC, and resets the blanking flip-flop. When the sample rate one-shot output goes low again, the NAND gate following is enabled. The output of this gate drives an OR gate which in turn triggers the start/reset one-shot. This completes one cycle.

4-55. The cycle is modified when automatic ranging is selected. Assume that an unknown input voltage is applied and the measurement cycle starts. The integrator and clock circuits function normally, and

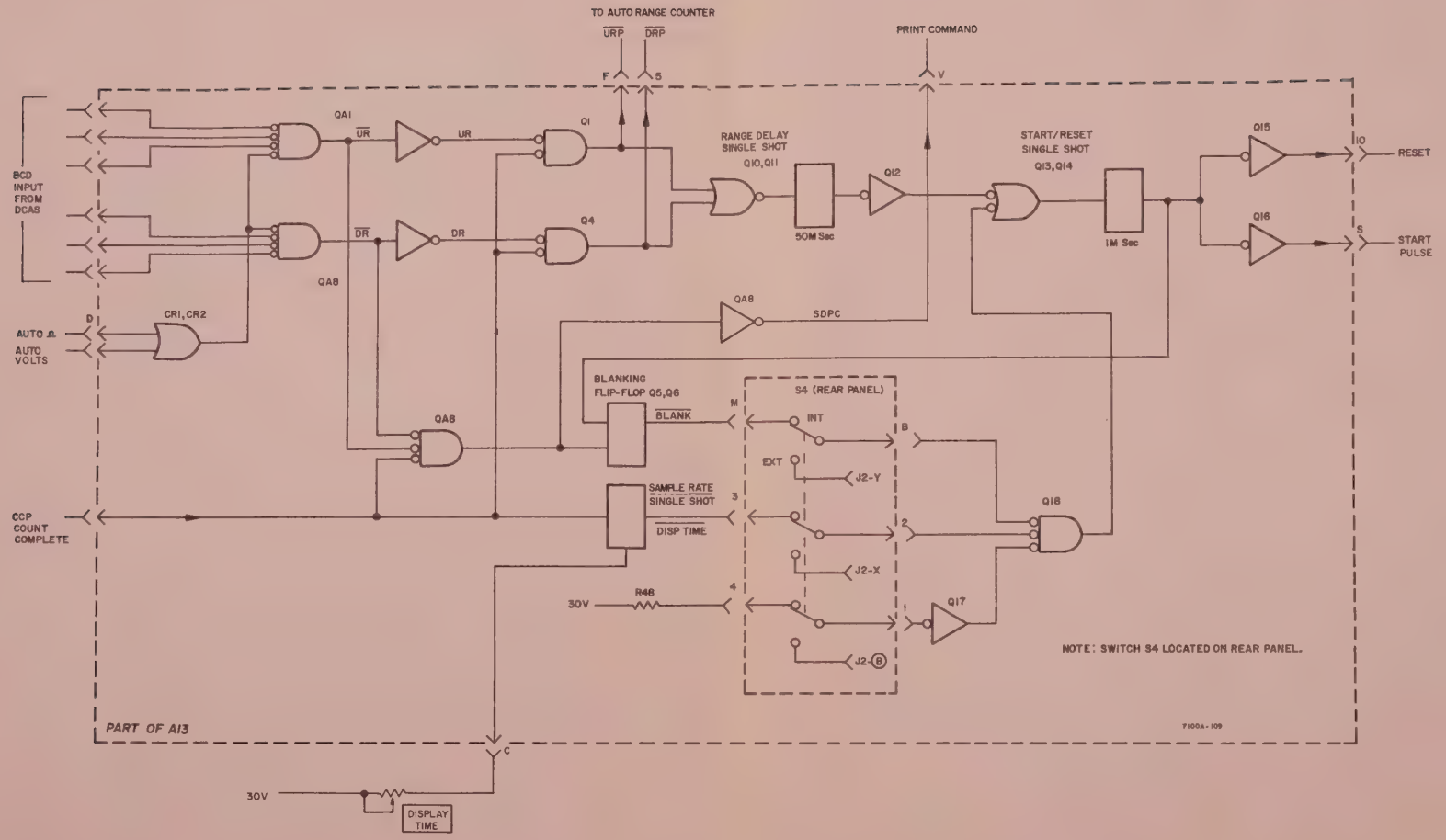


Figure 4-20 Control Logic

when a zero crossover is detected, the CCP pulse enables the two NAND gates in the autorange circuit. If the BCD input from the counter indicates that the counter reads over 16000, the up-range gate is enabled, and pulse $\overline{URP}$ drives the auto-ranging ring counter to the next higher range. If the count is below 01399, the down-range gate is enabled and $\overline{DRP}$ drives the ring counter to the next lower range. If either upranging or downranging signal is present, the print command pulse is not activated, nor is the blanking flip-flop reset. After a delay of approximately 50 msec to ensure relay closure and amplifier settling in the input circuit, the start/reset one-shot starts another measurement cycle. The upranging or downranging process continues until the proper range is found. After one measurement cycle on that range, the uprange or downrange pulses are not present and the display and print command signals allow the measurement to be viewed.

4-56. The start of the cycle may also be controlled by an external signal if Option 03 or 04 is installed. If the INT/EXT switch is in the EXT position, gate A13Q18 is disabled. The start/reset one-shot will then be triggered only when a positive-going external trigger signal is applied to the trigger input. Once a cycle is started the blanking flip-flop prevents the start/reset one-shot from being triggered until the CCP pulse resets the flip-flop at the end of a measurement.

4-57. Count Complete Circuit

4-58. The count complete circuit, part of power supply and logic assembly A20, detects counting action in the first decimal counter. When the count stops, indicating completion of a measurement, the circuit generates a pulse which is used in the control logic.

4-59. The circuit, shown in figure 4-21, consists of an amplifier, peak detector and memory, and pulse shaper. The input from the first counter, consisting of a square wave, is applied to the base of A20Q17, which amplifies the square wave and drives the peak detector composed of A20CR17 and A20CR18. The negative peak value of the square wave is stored by A20C7, which keeps A20Q18 turned on. Capacitor A20C8 is charged to 26.2 volts and A20Q19 is turned on due to bias from A20R35 and the +30 volt supply. A20Q20 is turned off by the low output from A20Q19. When the flow of clock pulses

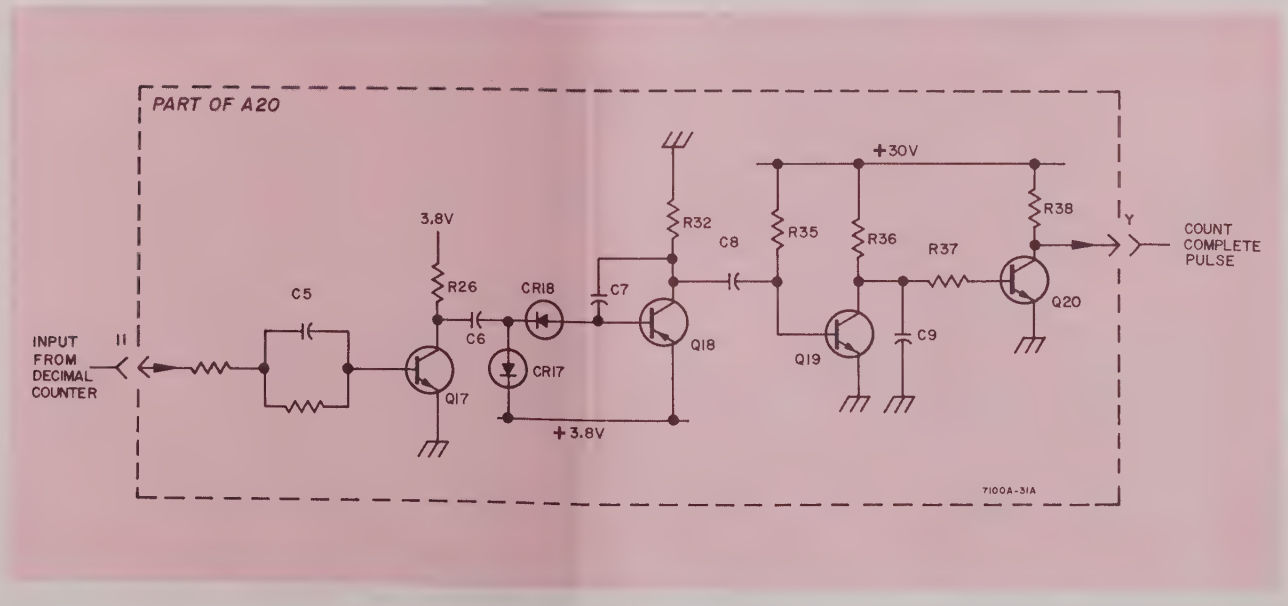


Figure 4-21. Count Complete Circuit

from the measurement circuit ends, A20C7 discharges and allows A20Q18 to turn off. This causes A20Q19 to turn off while A20C8 is charging to the new level. The positive-going output from A20Q19 is inverted by A20Q20 to drive the control logic. As soon as A20C8 is charged, A20Q19 turns on and the pulse is terminated. A20Q18 remains off until the counter starts again and A20C7 is charged.

4-60. COUNTER AND DISPLAY CIRCUITS

4-61. The complete counter consists of four scale-of-ten counter circuits and a binary counter, each with associated numeric indicator tube for display. Outputs also are available from each decade to drive optional format converters for 1-2-4-8 or 1-2-2'-4 binary-coded decimal recording of measurements.

4-62. Decimal Counter Units

4-63. A simplified diagram of decimal counter assemblies A15, A17, A18, and A19 is shown in figure 4-22. Each assembly is identical, and is connected in cascade; the output of the first drives the second, etc. The portion of the circuit which does actual counting consists of four flip-flops with gating to force the normal scale of 16 to a scale of 10. The resulting binary states conform to 1-2-2'-4 code, shown by the table in figure 4-22. The output of each flip-flop drives a second flip-flop, which stores the binary state of the driver. The output of the storage flip-flops go to a set of decoding gates which drive the indicator tubes. The storage flip-flops normally are gated off, and do not change states in unison with the counter flip-flops. After the counter has accumulated clock pulses during the measurement period, enabling signal SDPC allows the storage flip-flops to change to match the binary state of the counter flip-flops.

4-64. The operation of the counter is described in the following column.

a. The first negative-going transition to the input switches flip-flop A from the "0" to the "1" state.

b. The second transition switches A back to the "0" state. The output from A switches B to the "1" state.

c. The third transition switches A to the "1" state.

d. The fourth transition switches A to the "0" state. The output from A switches B to the "0" state. The output from B activates gate E which switches D to the "1" state. The output from D switches B back to the "1" state.

e. The fifth transition switches A to the "1" state.

f. The sixth transition switches A to the "0" state. The output from A switches B to the "0" state. The output from B Switches C to the "1" state. The output from gate E switches D to the "0" state, but the inverted output from C switches it back to the "1" state.

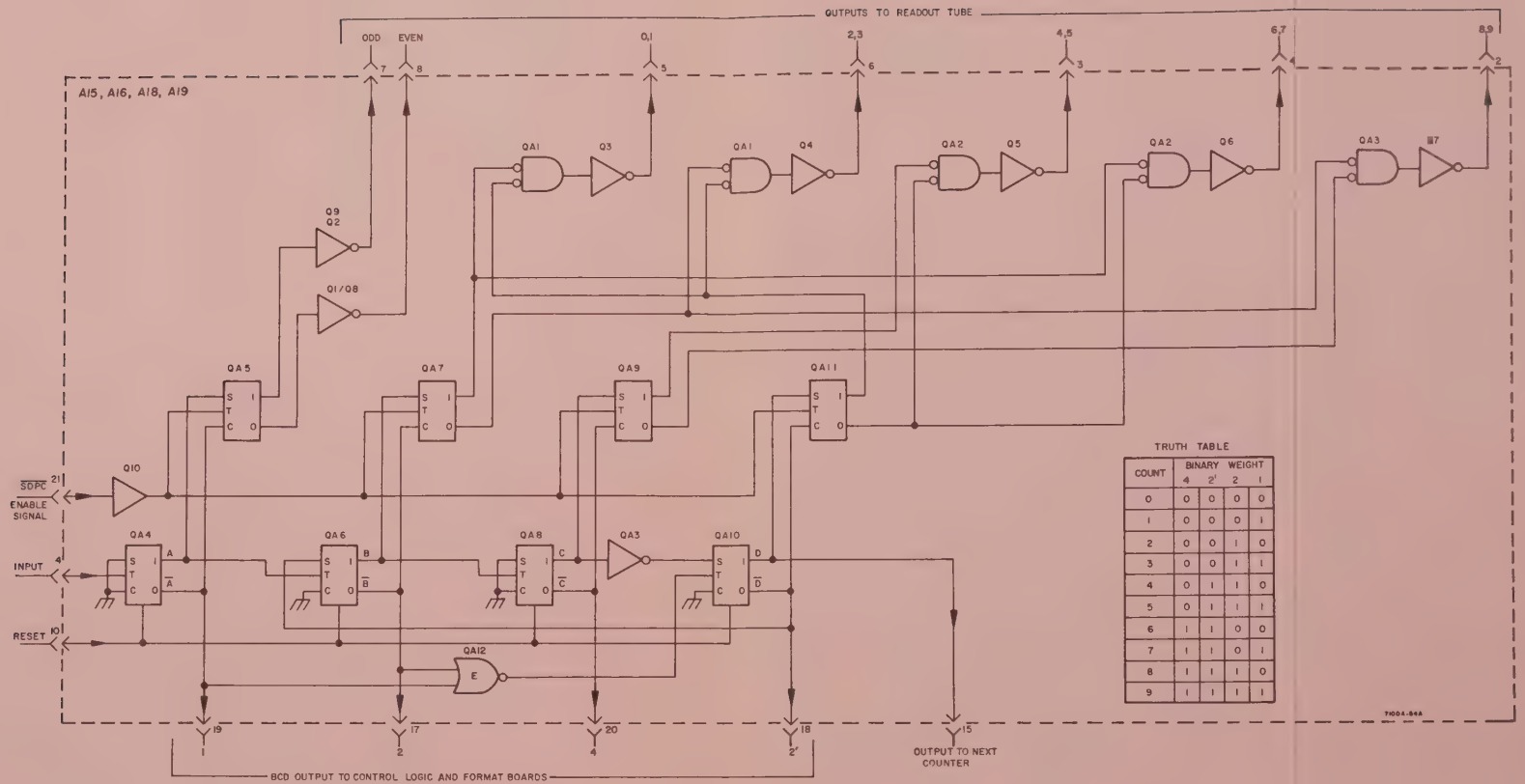
g. The seventh transition switches A to the "1" state.

h. The eighth transition switches A to the "0" state. The output from A switches B to the "1" state.

i. The ninth transition switches A to the "1" state.

j. The tenth transition switches A to the "0" state. The output from A switches B to the "0" state. The output from B switches C to the "0" state. The output from gate E switches D to the "0" state. The counter is now returned to its original state.

4-65. The storage flip-flops are driven directly by the 1 and 0 outputs of the counter flip-flops. During the interval that the clock is on and the counter is accumulating pulses, print command signal SDPC is



COUNT	BINARY WEIGHT 4	2'	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	1	0
5	0	1	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1

Figure 4-22 . Decimal Counter

low. The output of the inverter holds the storage flip-flops in the state assumed after the previous counting interval. When the measurement cycle has ended, SDPC goes high and the storage flip-flops assume the states of the counter flip-flops.

4-66. The output of the storage flip-flops drives a set of gates which convert the 1-2-2'-4 binary code to biquinary code required by the indicator tubes. The gates in turn drive amplifiers which are connected directly to the seven cathodes of the tube. The first flip-flop provides gating for the odd and even anodes of the tube (see figure 4-23). The outputs from the remaining gates activate the cathodes of the tube in 2-digit increments. If the decoded digit is 0 or 1, the first gate activates the 0, 1 cathode. The odd or even gating then determines which tube element lights. The same is true for the remaining digits.

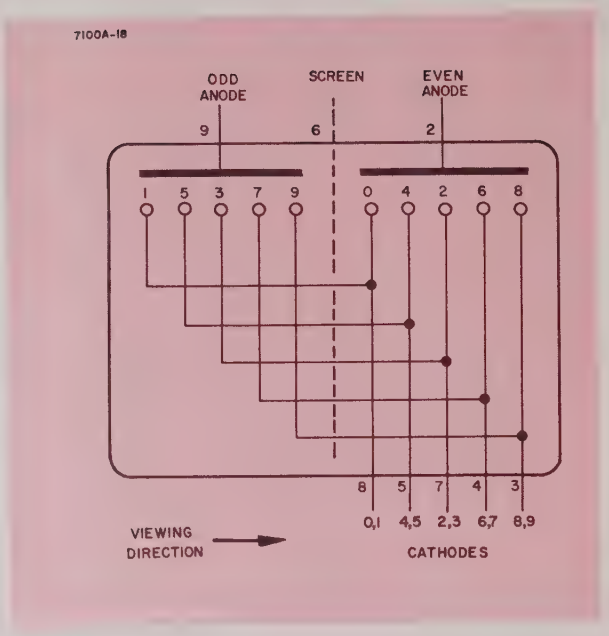


Figure 4-23. Numeric Indicator Tube

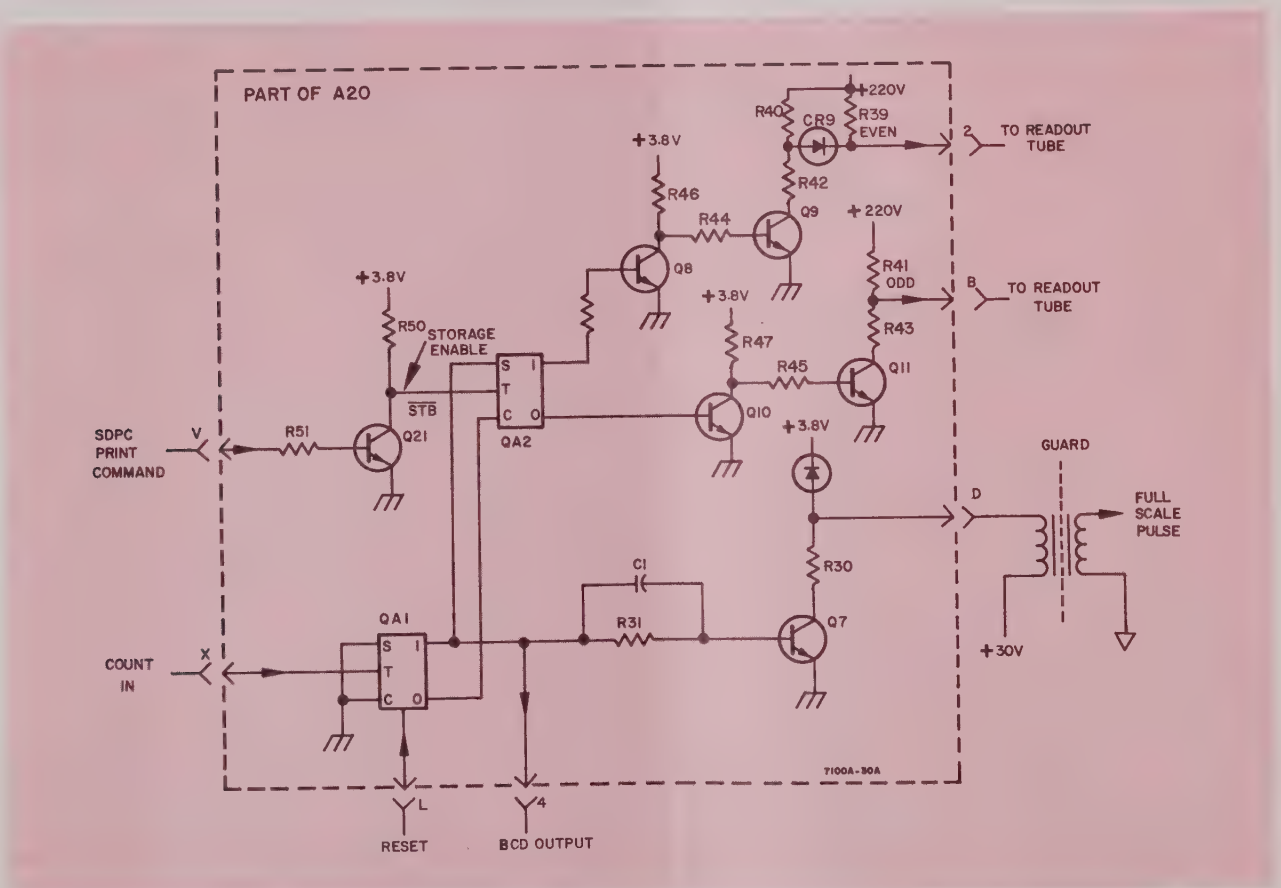


Figure 4-24. Binary Counter

4-67. BINARY COUNTER

4-68. The most significant digit of the counter is either 0 or 1, so the counter for that digit consists of a single flip-flop. See figure 4-24. The counter is nearly identical to the first binary stage of the decade counter assemblies. An additional gate circuit is driven by the counter flip-flop to provide the "full scale" pulse for the measurement circuit. Gate circuits which drive the odd and even anodes of the tube are mounted on the same circuit board. As in the other counters, the storage flip-flop does not assume the binary state of the counter flip-flop until enabled by print command SDPC.

4-69. The most significant digit counter differs from the other counters in that it is reset to 1 instead of 0. When the measurement cycle begins the counter is reset to 10000. After 9999 counts, the second digit overflows and the counter now registers 00000. The gate circuit connected to the counter flip-flop sends a pulse to the analog portion of the instrument to indicate that the counter has overflowed and activate the integrator input switch circuits.

4-70. DISPLAY LOGIC

4-71. The measurement result display consists of five decimal digits, a decimal point, polarity sign, and units display. The decimal digits are controlled by the counter circuits discussed previously. The decimal point and units display are controlled by a range/mode matrix circuit. The polarity display is controlled by a flip-flop triggered by the polarity pulse from the analog circuits. The following paragraphs describe each display circuit.

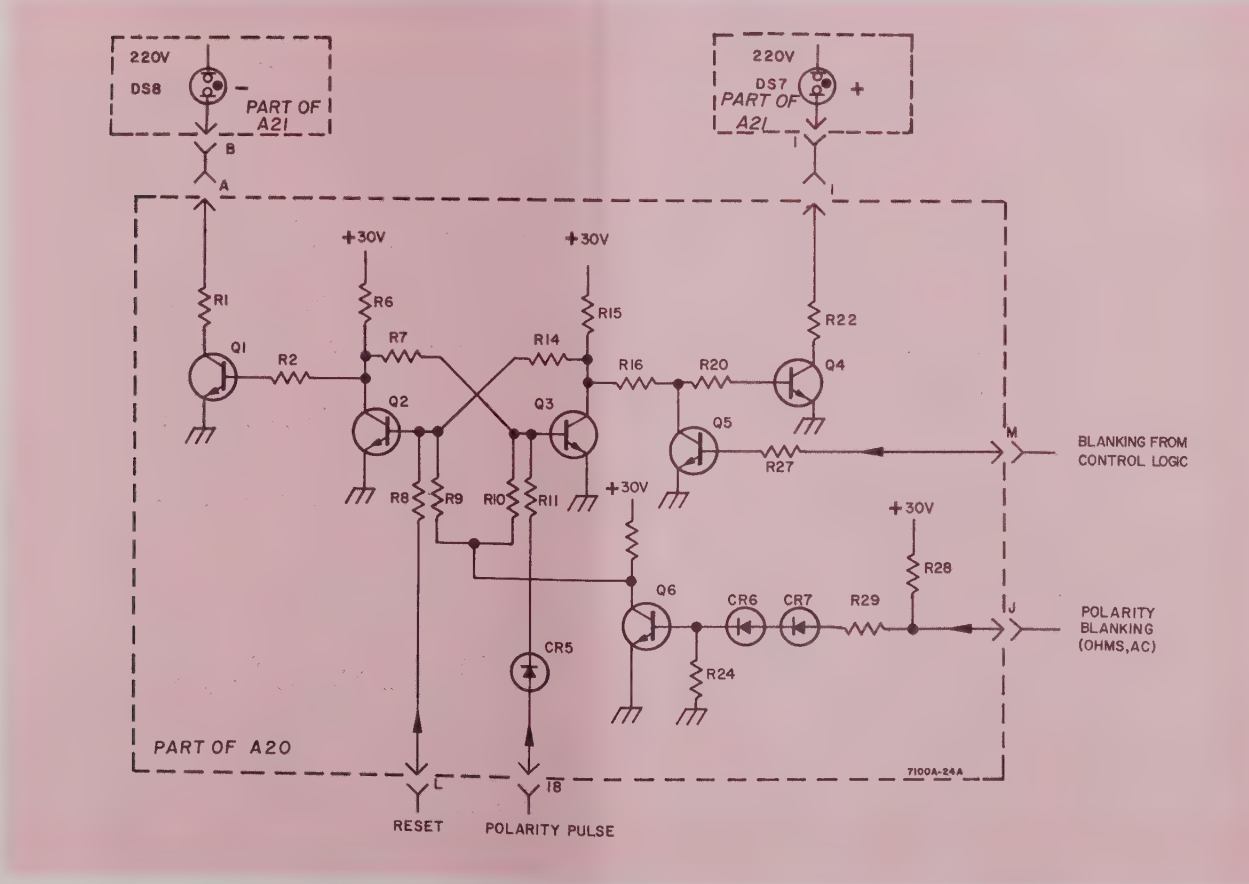


Figure 4-25. Polarity Display Circuit

4-72. Polarity Display

4-73. The polarity display circuit is shown in figure 4-25. Flip-flop A20Q2/A20Q3 is reset by the leading edge of the reset pulse from the control logic. In the reset condition A20Q2 is conducting and A20Q3 is not conducting. Under normal circumstances this would cause the + indicator to light, but the leading edge of the start pulse also triggers the blanking flip-flop in the control circuit. This causes control signal BLANK to go high and hold off the driver for the + indicator. At the time of the full scale pulse, the polarity logic in the analog circuits determines the polarity of the input signal. If the polarity is positive, no pulse is transmitted to the polarity display flip-flop. If the polarity is negative, a positive pulse is transmitted and the flip-flop changes states. When a mode is selected which does not require polarity indication (ohms, AC volts) a signal from range/mode matrix A12 gates on Q6 which clamps the bases of both sides of the flip-flop. This gates off both polarity indicators.

4-74. Decimal Point And Units Display

4-75. The display of decimal point and units is controlled by the range selected by manual range/mode switch or by automatic ranging circuits. Refferring to figure 4-26, the indicators are connected to the output of two-stage gated driver circuits. The inputs to the gate portion come from lines connected to the function/range switch. These lines also control relays (not shown) which select values in the input, clock, and integrator circuits. The gate transistors are normally held on by the 1 megohm resistor connected from the base to +30 volts. If either input is connected to ground through the function/mode switch, the gate transistor turns off, the driver transistor turns on, and the indicator lights. The Ω indicator circuit is unlike the others in that the circuit is held off in voltage, ratio, and check modes. In the resistance ranges the gate and driver stages turn on due to current through the coils of A9K14 and A9K17.

4-76. AUTO-RANGING CIRCUIT

4-77. The auto-ranging circuits are located on circuit board A11. The auto-ranging circuit, shown in figure 4-27, changes input ranges by counting uprange or downrange pulses from the control circuits (refer to paragraph 4-50). The resistance and voltage range relays are operated separately with each set of relay drivers being enabled by the VOLTS AUTO and OHMS AUTO positions of the function/range switch. Referring to figure 5-20, the output of each relay driver goes to mode matrix board A12 and energizes the range and mode lines in parallel with the function/mode switch. The uprange pulses are connected to drive the ring counter in one direction while the downrange pulses drive the counter in the other direction.

4-78. FORMAT CONVERSION CIRCUIT (OPTIONS 03 AND 04)

4-79. If optional remote programing and readout capability are installed, two circuit boards (A14 and A17) are added, as well as the rear-panel connectors and associated wiring. In option 03, the 1-2-2'-4 output from the counters is brought out through buffer stages, and decimal point data is encoded in 1-2-2'-4 BCD by the circuit shown in figure 4-28. In option 04, the 1-2-2'-4 output of the counters must be converted to 1-2-4-8. The conversion is done by the circuit shown in figure 4-29. Decimal point data is also converted to a 1-2-4 BCD as shown in figure 4-28.

4-80 POWER SUPPLIES

4-81. The power supplies used in the Model 7100A consist of three mounted outside the guarded area and two dual supplies mounted inside the guard. The supplies outside the guard are part of circuit board A20, and provide unregulated voltages of +30, and +220 volts, and regulated +3.8 volts. The supplies inside the guard provide + and - 30 volts, regulated.

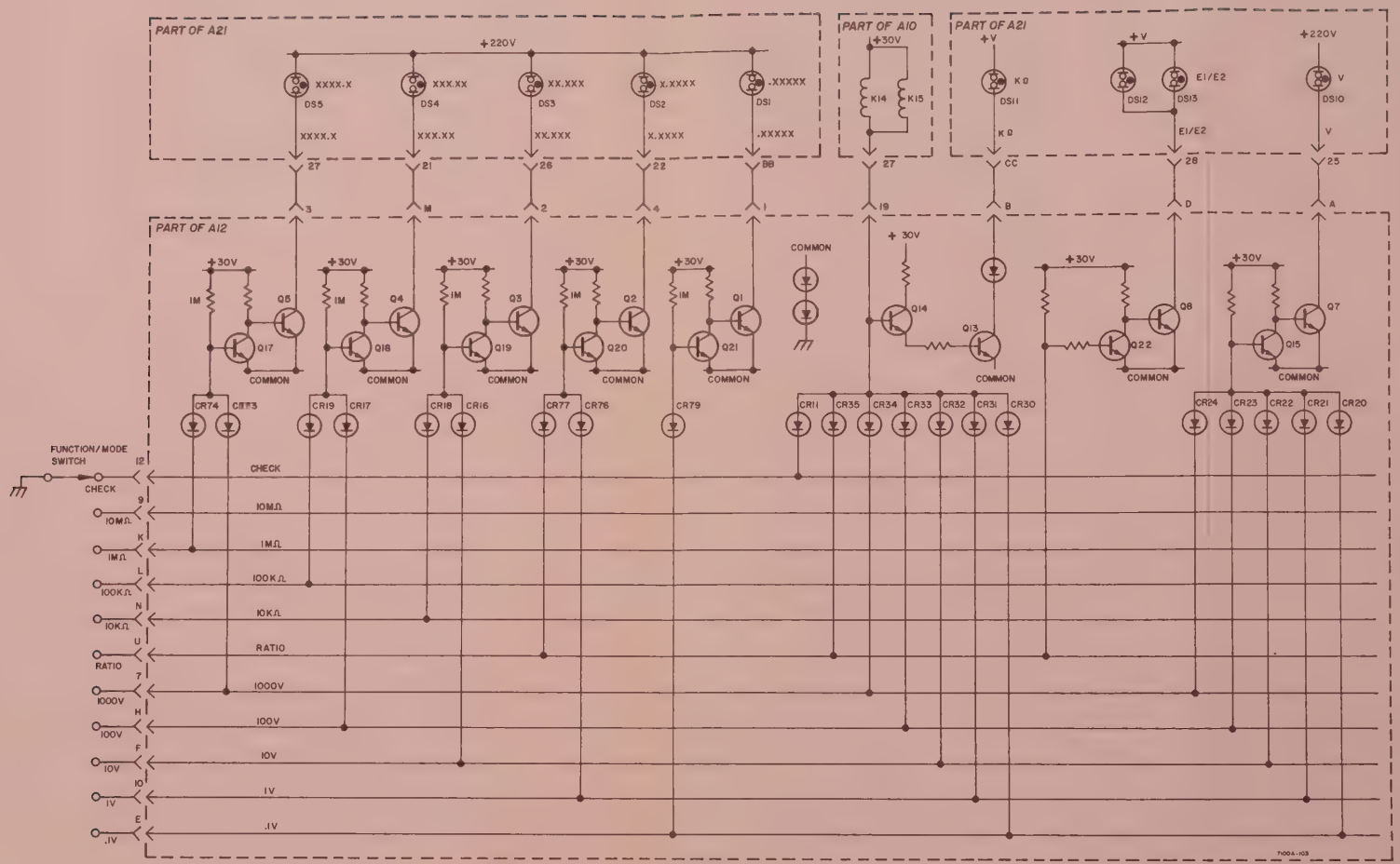


Figure 4-26. Decimal Point and Units Display Circuit

4-82. Supplies Outside Guard

4-83. Referring to figure 5-51, 30 volts for the logic circuits and 220 volts for the indicators are provided by two unregulated supplies. Both supplies consist of full-wave bridge rectifiers and filter capacitors. Ac input voltages to the bridges come from windings on power transformer T1.

4-84. Power for the integrated circuit elements used in the control and format circuits is provided by the regulated supply shown in figure 4-30. Diode A20CR16 provides a stable reference for differential amplifier A20Q15/A20Q16. Adjustment A20R13 allows the output to be set to exactly 3.8 volts. Any change in output is amplified by A20Q15 and A20Q14 and applied to series regulator A20Q13 to bring the output voltage back to the same level.

4-85. Supplies Inside Guard

4-86. Two dual supplies provide operating power for the measurement circuits inside the guarded enclosure. The supplies are identical, with outputs of + and - 30 volts. The supply on circuit board A5 is used for the input amplifier, and the other supply, mounted on circuit board A6, is used for the remaining circuits.

4-87. +30 Volt Supply. The positive supply is used to provide operating voltages for the measurement circuits and as a reference for the negative supply.

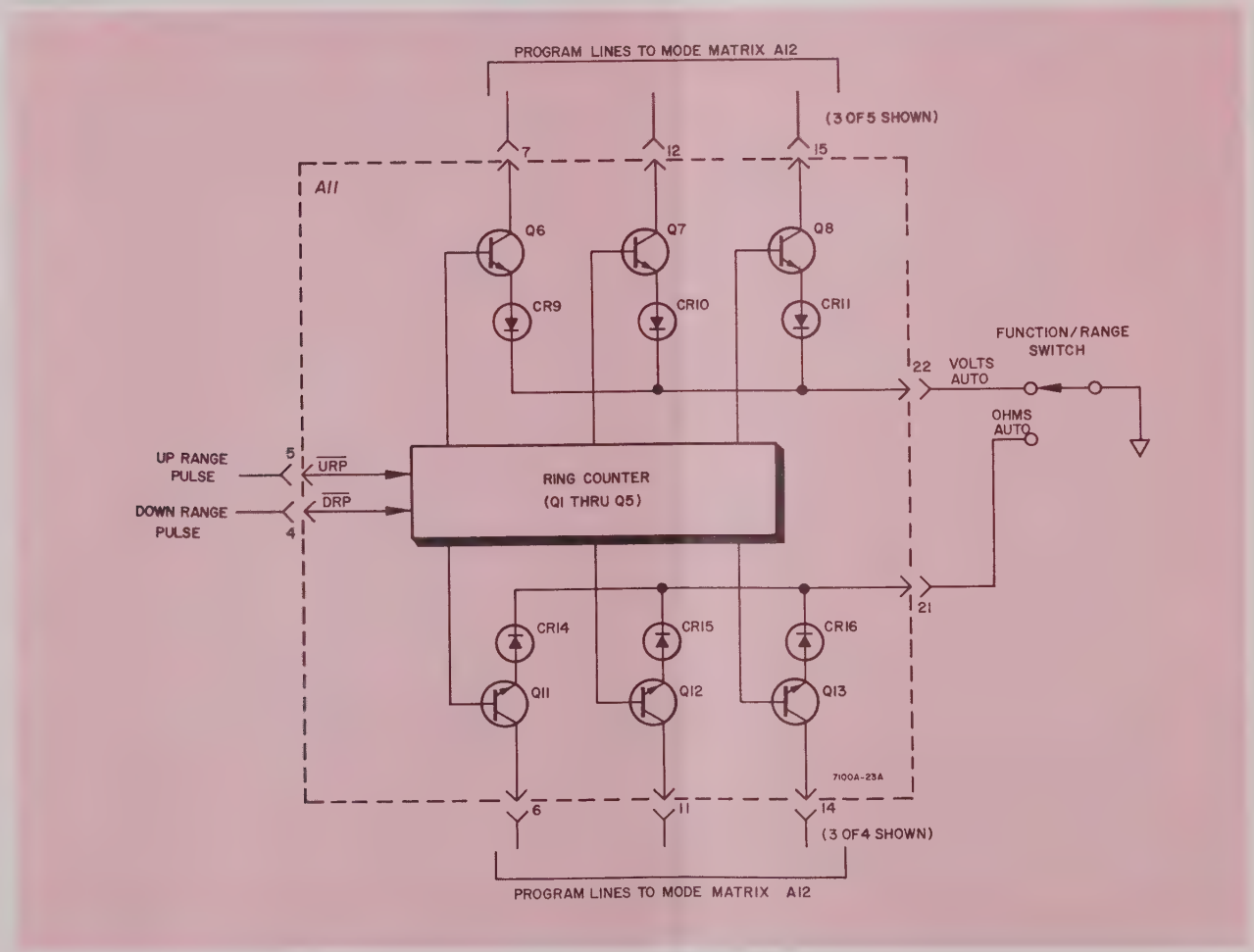


Figure 4-27. Auto-Ranging Circuit

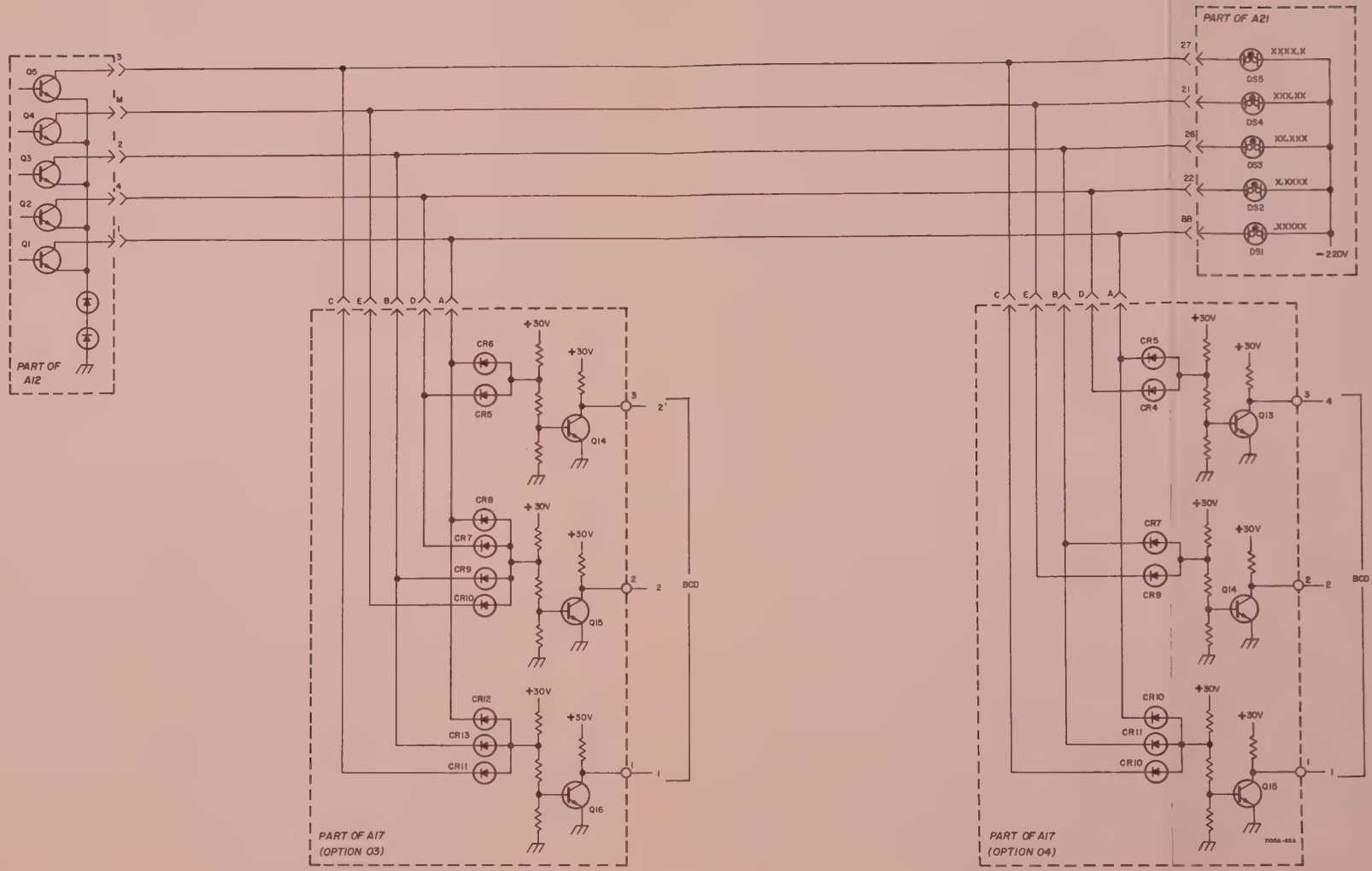


Figure 4-28. Decimal Point Encoders

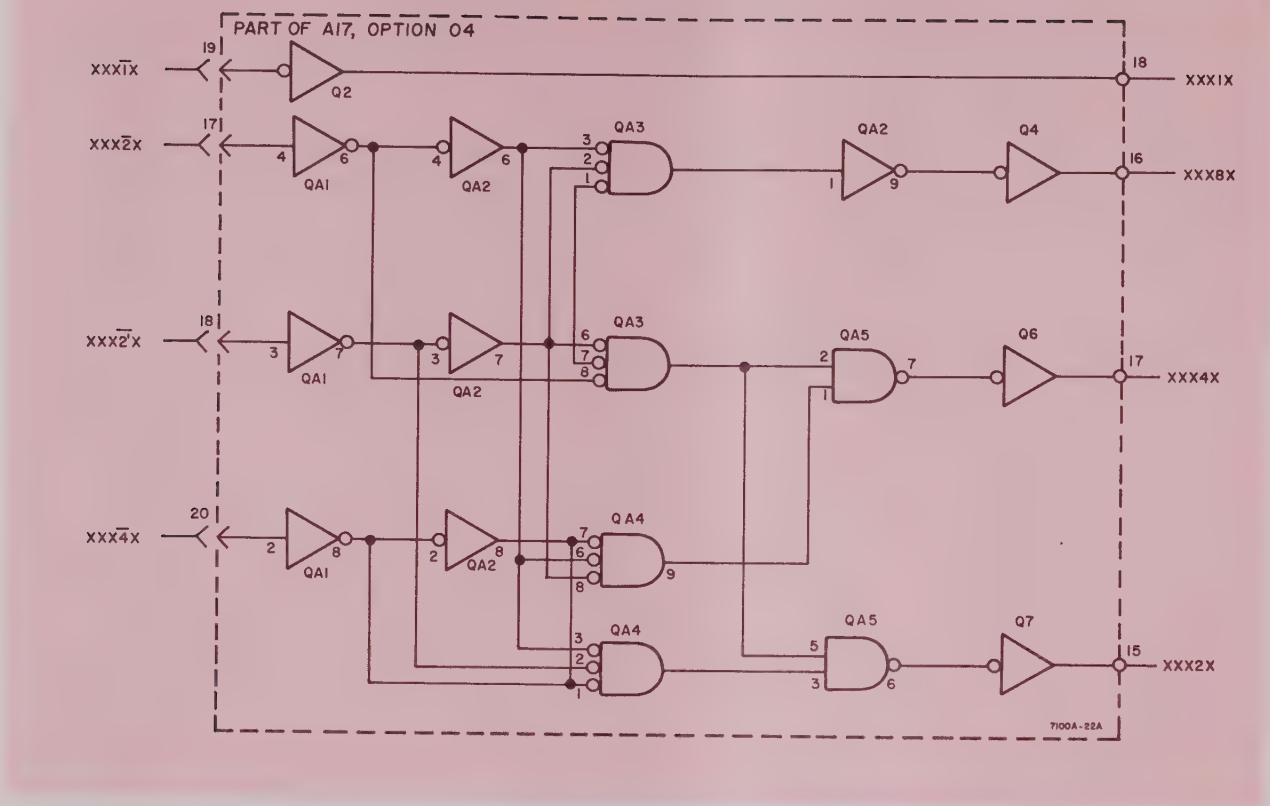


Figure 4-29. 1-2-4-8 Encoder Circuit

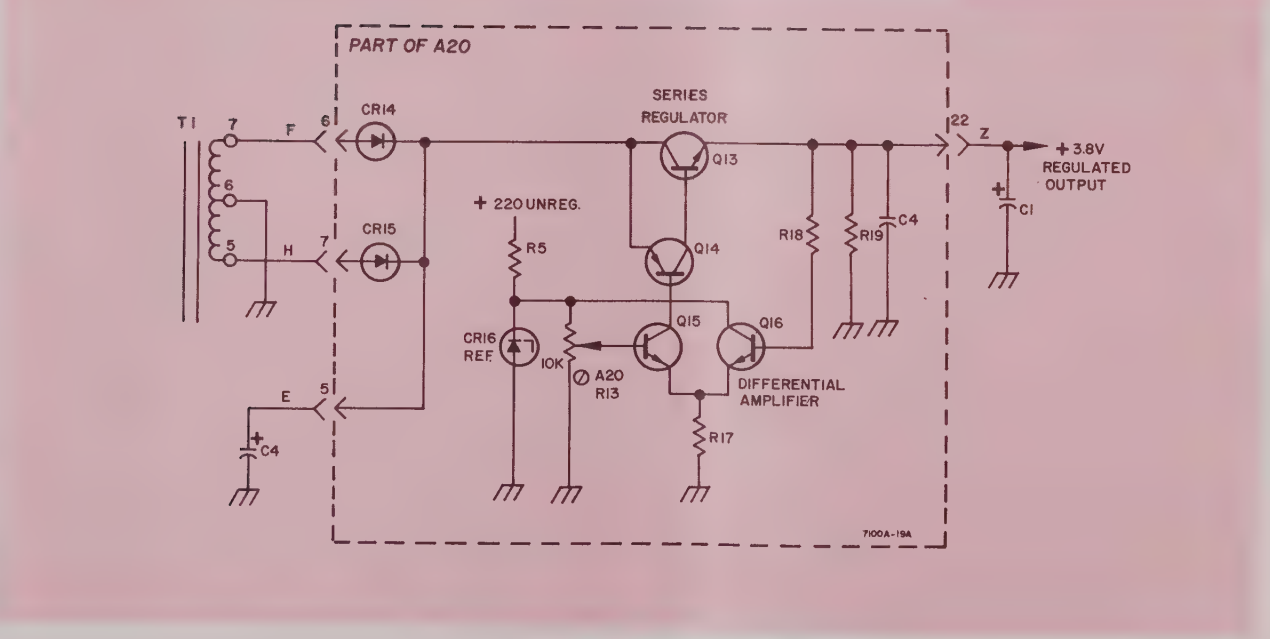


Figure 4-30. 3.8 Volt Regulated Supply

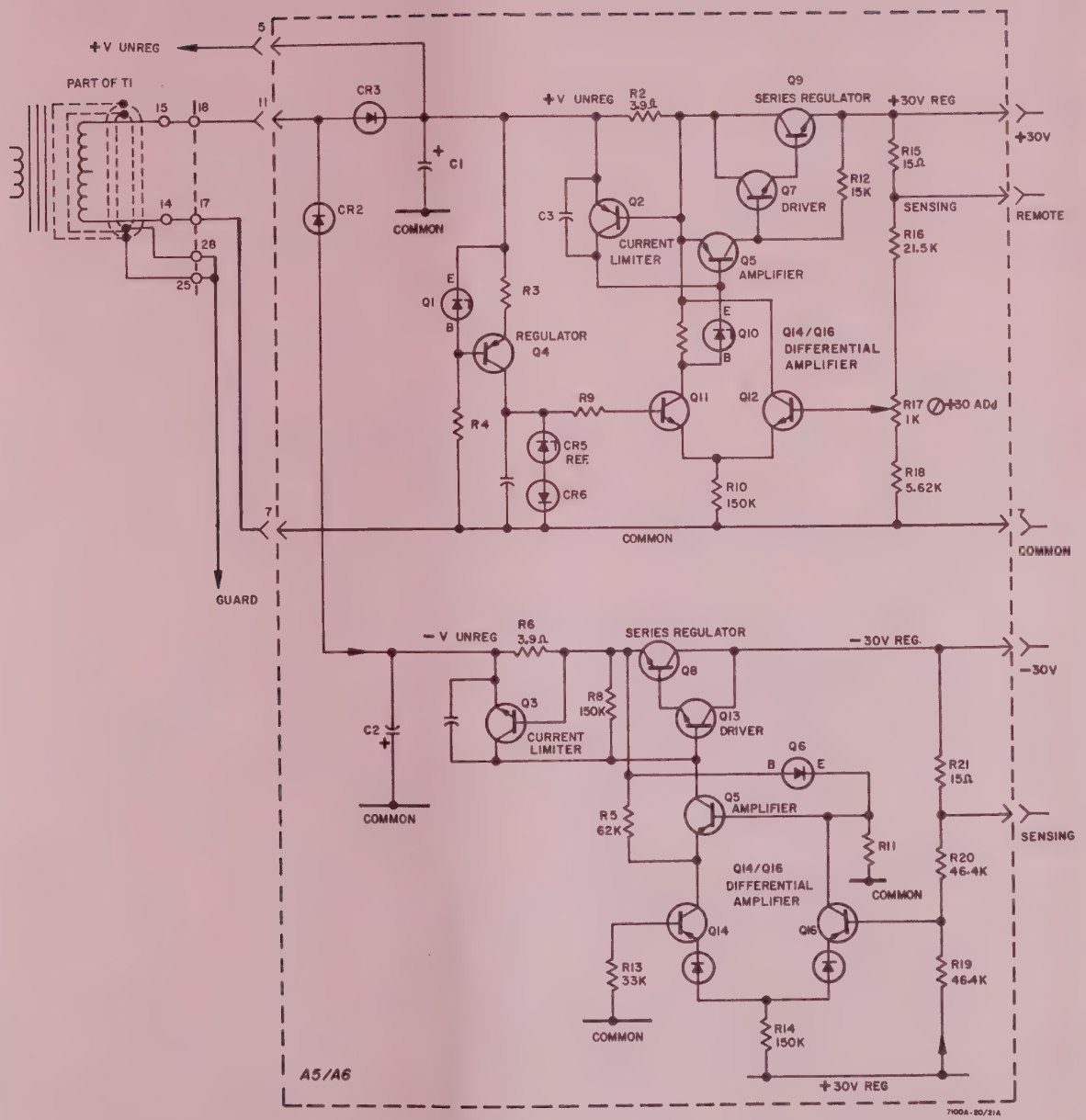


Figure 4-31. +30 V and -30V Regulated Supply

Referring to figure 4-31, the regulator circuits are conventional, using a differential amplifier which compares a sample of the output voltage with a stable reference voltage. Reference diode A5CR5 draws operating current from a simple regulated supply consisting of A5Q4 and A5Q1. Adjustment of the output voltage is provided by A5R17. Current limiting action is provided by A5Q2. If the voltage drop across A5R2 exceeds the base-emitter breakdown voltage of A5Q2, it turns on, drawing current from the base of A5Q5 and limiting the current available from the series regulator.

4-88. -30 Volt Supply. The negative supply is also conventional, using differential amplifier, driver stages, and series regulator. The reference for the differential comparison amplifier is the output of the positive 30 volt supply. The output level of the -30 volt supply is determined by fixed resistors A5R19 and A5R20, and by the level of the +30 volt supply. Current limiting is provided by A5Q3 operating in same manner as A5Q2 in the positive supply.

Section V
Maintenance

5-1. INTRODUCTION

5-2. This section contains information for calibration, maintenance, and troubleshooting of the Model 7100A. Also included is a list of test equipment required for procedures outlined in this section.

5-3. TEST EQUIPMENT REQUIRED

5-4. Table 5-1 lists test equipment required for performance check, troubleshooting, and adjustment. If the recommended equipment is not available, equipment with equivalent specifications may be substituted.

5-5. In procedures involving accurate dc voltage or resistance measurements, care must be taken to ensure consistent results. Working standards should be referred to primary standards on a regular basis. Particular care should be taken with resistance standards which are subject to long-term drift due to aging.

5-6. PERFORMANCE CHECK

5-7. The performance check outlined in the following paragraphs is used to verify the specifications of the Model 7100A. It can be used upon receipt of a new instrument, for routine preventive mainten-

Table 5-1. Required Test Equipment

Equipment Type	Required Specifications
Voltage Standard	Output: 0 - 1100 vdc, decade steps; Accuracy: ±0.003% of setting
Voltage Source	Output: +5, +10, +15 vdc; Accuracy: ±0.003%
Resistance Standard	Resistance: 1000 Ω to 16 megohms, decade steps Accuracy: ±0.005% of setting.
Audio Oscillator	Frequency Range: 20 Hz to 1 kHz Output Amplitude: 0 to 200 v p-p into 10 k ohms
Variable Autotransformer	Output: 0 - 115 vac, 60 Hz
Line Voltage Meter	Range: 105 to 125 vac, 60 Hz; Accuracy: ±1%
Standard Resistors	Values: 10 k, 100 k, 1 M, 10 M; Accuracy: ±0.005%
Filament Transformer	Primary Input: 115 vac, 60 Hz Secondary Output: 12.6 vac

ance, and following repair.

5-8. Resistance Accuracy Check

5-9. To check resistance measurement accuracy, use the following procedure:

a. Connect test cable to OHMS input connector.

b. Connect decade resistance box between high and low jacks on test cable. Connect guard to ground terminal. Set resistance to zero.

c. Set instrument function/range switch to 10 k OHMS position.

d. Note readout. It should be 00.001 k or less.

e. Check remainder of resistance settings and ranges as listed in table 5-2. Note that the reading is within the tolerance shown in each case.

f. Disconnect resistance box.

Table 5-2. Resistance Accuracy

Range	Resistance Setting	Readout Limits	
		Maximum	Minimum
10 K OHMS	00.000	00.001	00.001
	1.600 kΩ	01.601	01.599
	8.000 kΩ	08.002	07.998
	16.000 kΩ	16.003	15.997
100 K OHMS	000.00	000.01	000.01
	16.00 kΩ	016.01	015.99
	80.00 kΩ	080.02	079.98
	160.00 kΩ	160.03	159.97
1 M OHM	0000.0	0000.1	0000.1
	160.00 kΩ	0160.1	0159.9
	800.00 kΩ	0800.2	0799.8
	1.6000 MΩ	1600.3	1599.7
10 M OHMS	00000	00001	00001
	1.600 MΩ	01601	01599
	8.000 MΩ	08003	07997
	16.000 MΩ	16005	15995

5-10. Voltage Accuracy Check

5-11. To check accuracy of voltage measurement, proceed as follows:

a. Connect test cable to front-panel VOLTS connector.

b. Connect test cable banana jacks to high and low output terminals of voltage standard. Connect guard jack to ground terminal.

c. Set output of voltage standard to zero.

d. Set Model 7100A Mode/Range switch to .1 VOLTS position.

e. Note readout. It should be between -.00002 and +.00002 V.

Table 5-3. Voltage Accuracy

Range	Voltage Setting	Readout Limits	
		Maximum	Minimum
.1 VOLTS	.00000 V	.00002	.00002
	.01600 V	.01602	.01598
	.08000 V	.08003	.07997
	.16000 V	.16004	.15996
1 VOLT	0.0000 V	0.0001	0.0001
	0.1600 V	0.1601	0.1599
	0.8000 V	0.8002	0.7998
	1.6000 V	1.6003	1.5997
10 VOLTS	00.000 V	00.001	00.001
	01.600 V	01.601	01.599
	08.00 V	08.002	07.998
	16.000 V	16.003	15.997
100 VOLTS	000.00 V	000.01	000.01
	016.00 V	016.01	015.99
	080.00 V	080.02	079.98
	160.00 V	160.03	159.97
1000 VOLTS	0000.0 V	0000.1	0000.1
	100.0 V	0100.1	0099.9
	500.0 V	0500.1	0499.9
	1100.0 V	1100.2	1099.8

f. Check accuracy at each setting of voltage standard listed in table 5-3. In each case the readout should be within the tolerance shown.

5-12. Voltage Ratio Accuracy Check

5-13. To check accuracy of voltage ratio measurement, use the following procedure:

a. Set instrument Function/Range switch to RATIO 1.0.

b. Connect reference voltage supply to J6 on rear panel.

c. Connect voltage standard to VOLTS input connector on front panel.

d. Set reference supply for an output of 10.000 volts.

e. Set voltage standard for output of 10.000 volts.

f. Note readout. It should be between 0.9998 and 1.0002.

g. Check accuracy at points listed in table 5-4. Readout should be within limits shown in each case.

Table 5-4. Voltage Ratio Accuracy

Reference Input (J6)	Standard Input (Volts Connector)	Readout Limits	
		Maximum	Minimum
	1.600 V	0.1601	0.1599
+10 V	8.000 V	0.8003	0.7997
	16.000 V	1.6005	1.5995
	2.00 V	0.1601	0.1599
+15 V	12.00 V	0.8003	0.7997
	15.00 V	1.6005	1.5995

h. Disconnect equipment.

5-14. DC Common Mode Rejection

5-15. To check dc common mode rejection ratio, proceed as follows:

a. Connect test equipment as shown in figure 5-1.

b. Set power supply output to zero.

c. Set Function/Range switch to .1 V position.

d. Note readout. Increase power supply output to 500 volts.

e. Note readout. Reading should not have changed from that observed in step d.

f. Disconnect test equipment.

5-16. AC Common Mode Rejection

5-17. Check ac common mode rejection as follows:

a. Connect test equipment as shown in figure 5-2. Set S2 on Model 7100A for long integration time.

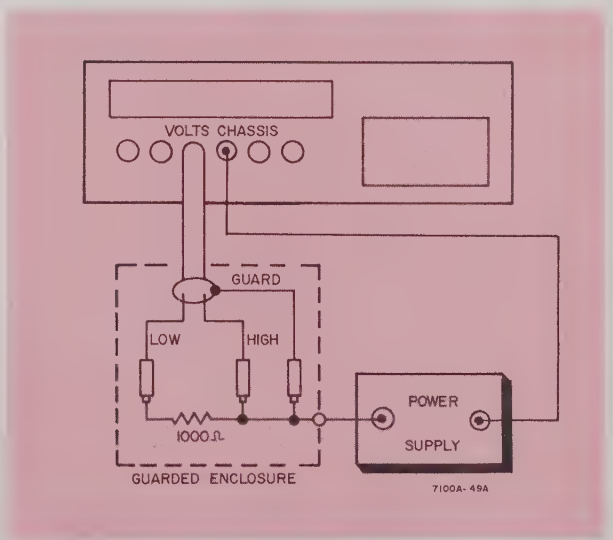


Figure 5-1. Test Set-Up DC Common Mode Rejection

b. Adjust oscillator for zero output.

c. Set Function/Range Switch to 1.0 volts. Note readout. Increase oscillator output to 200 V p-p (71.4 V rms). Vary oscillator frequency from 20 Hz to 1 kHz.

d. Note readout. It should be the same as observed in step c. No instability of reading should be noted, but polarity sign may change.

e. Disconnect test equipment.

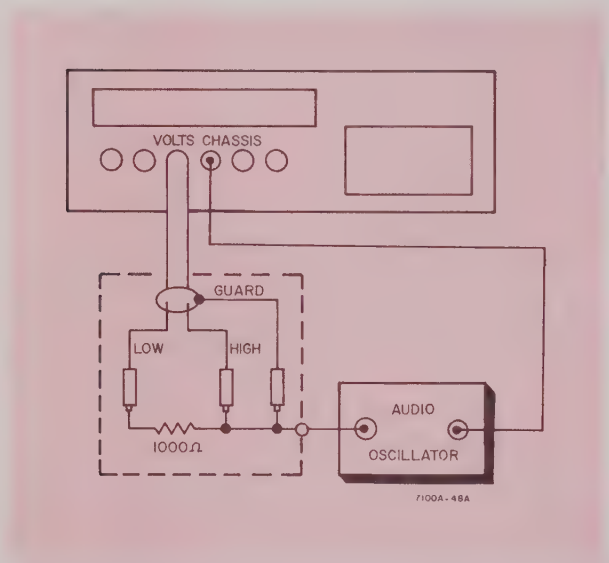


Figure 5-2. Test Set-Up AC Common Mode Rejection

5-18. Normal Mode Rejection

5-19. To check normal mode rejection:

a. Connect test equipment as shown in figure 5-3.

b. Set Function/Range switch to 10 VOLTS position. Set S2 for long integration time.

c. Adjust oscillator for zero output and note readout.

d. Set oscillator frequency to 55 Hz and increase output to 2 V p-p (.072 V rms).

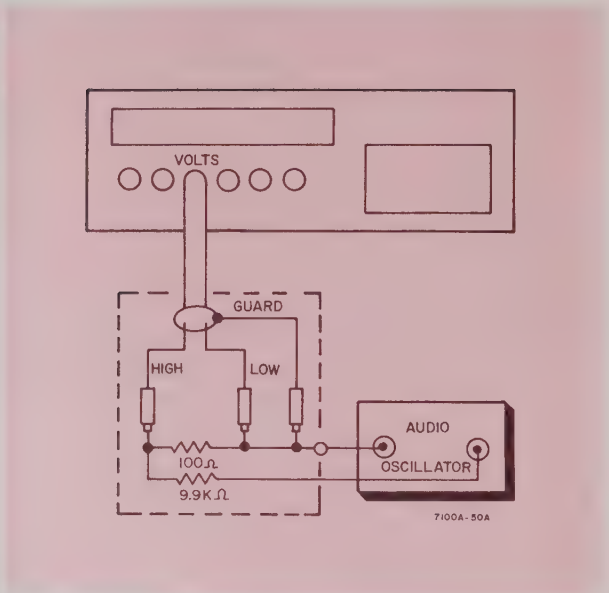


Figure 5-3. Test Set-Up 55 Hz Normal Mode Rejection

e. Note readout. It should be the same as observed in step d. No instability of reading should be noted, but polarity sign may change.

f. Disconnect test equipment. Connect test equipment as shown in figure 5-4.

g. Set Function/Range switch to 10 VOLTS position.

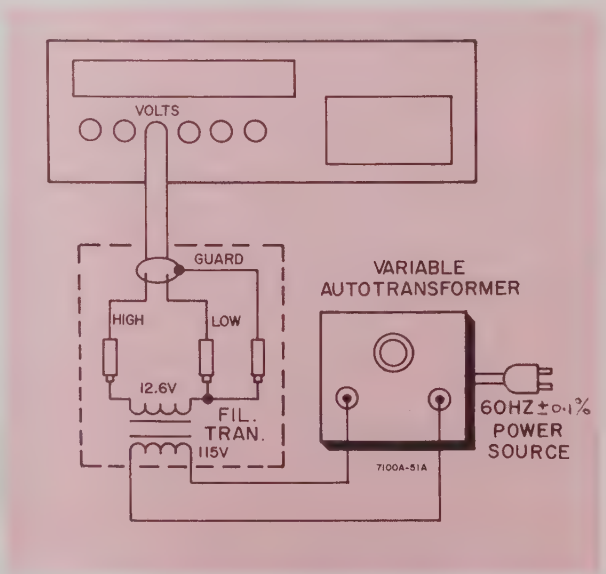


Figure 5-4. Test Set-Up 60 Hz Normal Mode Rejection

h. Set S2 on instrument rear panel to long integration time.

i. Increase variable autotransformer output until OVERLOAD indicator goes on, then reduce output until indicator just goes out.

j. Note readout. No instability of reading should occur, but polarity sign may change.

5-20. Line Voltage Check

5-21. To check stability of instrument at low and high line voltage, use the following procedure:

a. Plug Model 7100A power cable into output of variable autotransformer.

b. Set autotransformer output to 115 volts.

c. Connect test cable to VOLTS input connector.

d. Connect output of voltage standard to test cable.

e. Set output of voltage standard to 15.000 volts. Set instrument Function/Range switch to 16 VOLTS position.

f. Note readout. Adjust autotransformer output to 105 volts.

g. Note readout. It should be the same as in step f.

h. Adjust autotransformer output to 125 volts.

i. Note readout. It should be the same as in step f.

j. Disconnect test equipment.

5-22. Automatic Ranging Check

5-23. To check automatic ranging, use the following procedure.

a. Connect output of voltage standard to front-panel VOLTS connector.

b. Set Function/Range switch to AUTO VOLTS position.

c. Set voltage standard output to 0.15999. Instrument should read on the .1 volt range.

d. Set voltage standard output to 0.16000 volts. Instrument should change to 1 volt range.

e. Set voltage standard output to .01400 volts. Instrument should stay in 1 volt range.

f. Set voltage standard output to .01399. Instrument should change to .1 volt range.

g. Check remaining ranges using table 5-5. Unit should change ranges at voltages listed.

Table 5-5. Auto-Ranging

Range	Range Change Voltage	
	Up	Down
1.6 V	1.6000 V	0.1399 V
16 V	16.000 V	01.399 V
160 V	160.00 V	013.99 V
1100 V		0139.9 V

5-24. PERIODIC MAINTENANCE

5-25. The Model 7100A requires little periodic maintenance. The procedure in the following paragraphs may be used when maintenance is performed on a regular basis.

5-26. INSPECTION

5-27. Remove top and bottom covers from instrument. Inspect the chassis and mounted components for damage, signs of overheating, etc. Remove circuit boards and inspect for damage or signs of

failure. Using low pressure, dry, compressed air, blow out any dust accumulation.

NOTE

Do not touch any part of Range Assembly A9. Perspiration or oil from hands may cause leakage paths which affect calibration.

5-28. Rotate front-panel controls through full range, noting any binding or rough action. Lubricate ball action on Function/Range switch with lubriplate. Do not use silicone type lubricants.

5-29. Following inspection, replace all circuit boards and covers. Make performance check detailed in paragraphs 5-6 through 5-22.

5-30. AIR FILTER

5-31. When the air filter has trapped enough dirt to impede airflow it should be cleaned as follows:

a. Remove four screws and frame holding filter element.

b. Remove filter element.

c. Wash filter in warm water-detergent solution.

d. Dry filter thoroughly and replace.

NOTE

Do not use coating compound on filter. Filter is designed to be used dry.

5-32. ALIGNMENT PROCEDURE

5-33. Table 5-6 details the alignment procedure used to calibrate the Model 7100A for correct readout on all ranges. The procedure must be followed in the order given since there is interaction between adjustments. Figure 5-5 shows the location of the adjustment controls.

5-34. COMPONENT LOCATION AND SCHEMATIC DIAGRAMS

5-35. Figures 5-6 through 5-43 show location of components on circuit boards and schematic diagrams. Included in diagrams of the basic instrument are diagrams of optional features such as remote programing.

5-36. Waveforms included with schematics were made under the following conditions unless otherwise noted:

a. Oscilloscope used was Fairchild Model 766H with Type 74-03A horizontal plug-in.

b. Input signal dc coupled with 10 megohm, 10:1 probe.

c. Sweep triggering from A13-S (start pulse), negative slope, ac coupled.

d. Function/Mode switch in CHECK position.

Assembly	Figure Number		
	Waveform	Component Location	Schematic
A1	5-9	5-10	5-11
A2	5-12	5-13	5-14
A3	5-15	5-16	5-17
A4	5-18	5-19	5-20
A5, A6	----	5-21	5-22
A7	----	5-23	5-24
A8	----	5-25	5-26
A9	----	5-27	5-28
A11	5-29	5-30	5-31
A12	----	5-32	5-33
A13	5-34	5-35	5-36
(Option 03) A14	----	5-37	5-38
(Option 04) A14	----	5-39	5-40
A15, 16, 18, 19	5-41	5-42	5-43
(Option 03) A17	----	5-44	5-45
(Option 04) A17	----	5-46	5-47
A20	5-48	5-49	5-50
A21	----	5-51	5-52

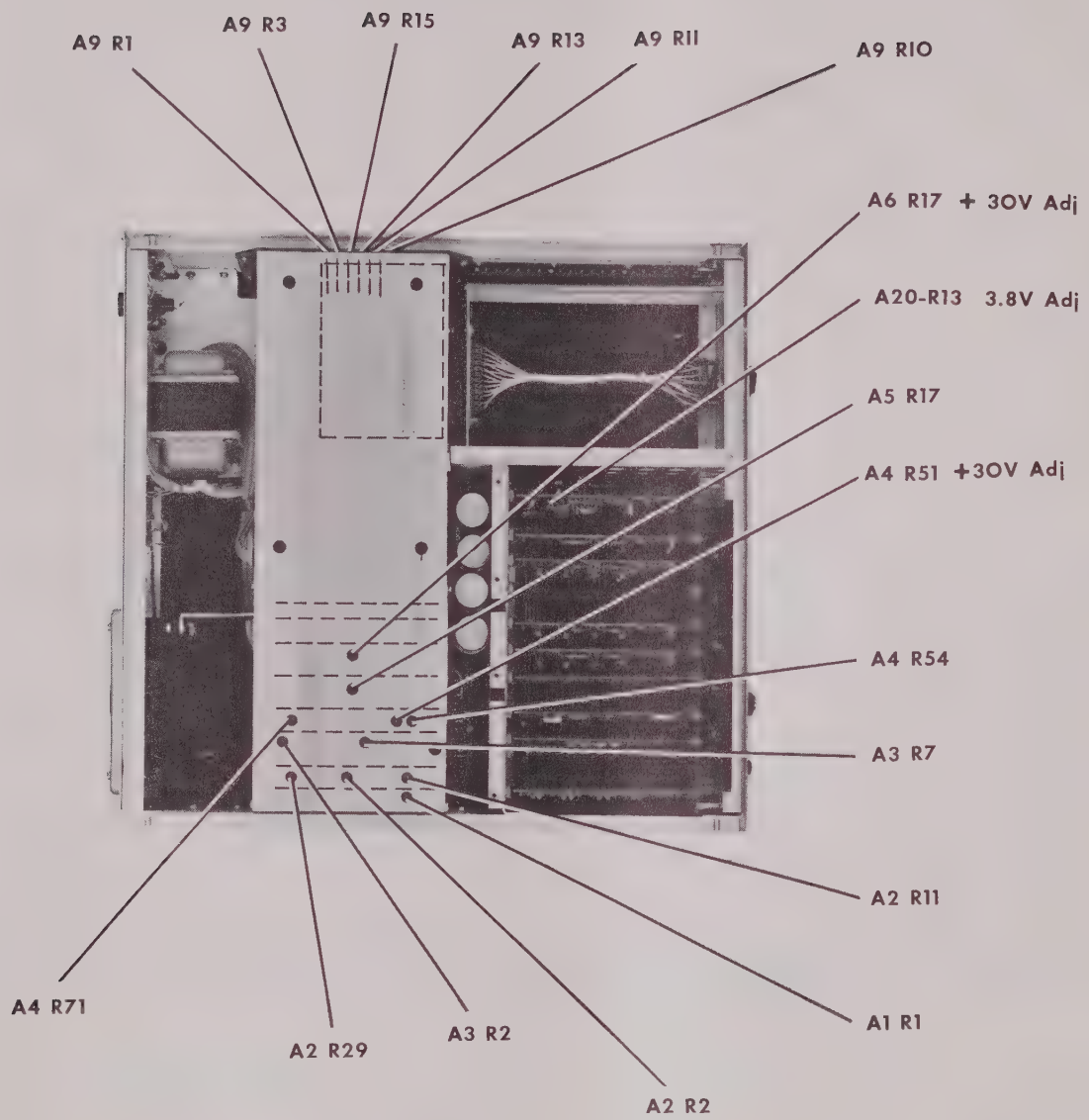


Figure 5-5. Adjustment Location Diagram

Step	Function/Range Switch Setting	Integration Time	Input	Adjustment
1	10 V	long	±30 mV	Place A4 on extender board. Apply power. Short emitter to collector of A4Q11. Note readout. Remove short connector. Adjust A4R51 one turn past the point where readout changes from 6 digits to 7 digits less than readout noted above.
2				Replace A4 in DVM. Replace A-D Converter Cover. Put Calibration Cover on DVM. Allow ½ hour warm-up.
3	10 V	long	±30 mV	Adjust A2R11 for symmetrical readout.
4	10 V	long	±30 mV	Adjust A2R2 for ±30 mV readout.
5	10 V	long		Readjust A2R11 (symmetry) and A2R2 (offset) until the reading changes from 0 to ±1 mV with a ±.7 mV to .9 mV input.
6	10 V	short		Apply ±5 mV. Adjust A37 for a symmetrical readout within ±.15 mV. Adjust A4R54 (Zero Dead Band) until readout changes from 0 to ±1 mV when the input is > ±.2 mV and < ±.8 mV. When adjusting A4R54, the readout will change one digit for each full turn in the direction of the desired change. Readjust A3R7 until readout changes from 0 to ±1 mV with a symmetrical input voltage ±.1 mV. When readout changes from 0 to ±1 mV, input voltage should be > ±.4 mV and < ±.8 mV. Apply a negative voltage in .1 mV steps starting at 0. If readout changes from 0 to +1 mV and then to -1 mV as the input increases, A4R54 is out of adjustment.
7	100 mV		±100 mV	Adjust A4R71 for a symmetrical readout.
8	Ratio	long	+10 V +10 V Ref.	Adjust A2R29 for a readout of 1.0000 approaching from the high side. NOTE Do not connect to the LOW of the reference input to the standard if the same standard is used for both inputs.
9	10 V	long	+16 V	Adjust A3R2 for readout of +16.000.
10	10 V	long	-16 V	Adjust A1R1 for readout of -16.000.
19	10 KΩ	long	16 KΩ	Adjust A9R15 for same readout produced on the 10 V range in the long integration with -16 V input.
20	100 KΩ	long	160 KΩ	Adjust A9R13 for a readout of the same absolute number in step 19.
21	1.0 MΩ	long	1.6 MΩ	Adjust A9R11 for a readout of the same absolute number in step 19.
22	10 MΩ	long	16 MΩ	Adjust A9R10 for a readout of the same absolute number in step 19.
23	100 V	long	160 V	Readout should be 10 times that produced for the same polarity input of 16 V into the 10 V range.
24	1000 V	long	1100 V 1100 V	Readout should be 100 times the readout produced for the same polarity input of 11 V into the 10 V range. Adjust A9R10, if required.
25	10 MΩ	long	16 MΩ	If readjustment was required in step 24, the readout should be the same absolute number as in step 19 ±1 digit.
26	Auto Volts	long & short		Apply inputs to cause the DVM to range from the 100 mV range to the 1 KV range and back. The speed of auto ranging should not be effected by the position of the "Sample Rate" control.
11	10 V	short	-16 V	Readout should be -16.000 ±1.
12	10 V	short	+16 V	Readout should be +16.000 ±1.
13	Check	short	--	Readout should be 10000 ±1.
14	Check	long		Readout should be 10000.
15	1.0 V	long	±1.6 V	Adjust A9R3 for readout of ±1.6000.
16	1.0 V	short	±1.6 V	Readout should be ±1.6000 ±1 digit.
17	100 mV	long	±.16 V	Adjust A9R1 for readout of ±.16000.
18	100 mV		±.16 V	Readout should be ±.16000 ±1 digit.

Table 5-6. Alignment Procedure

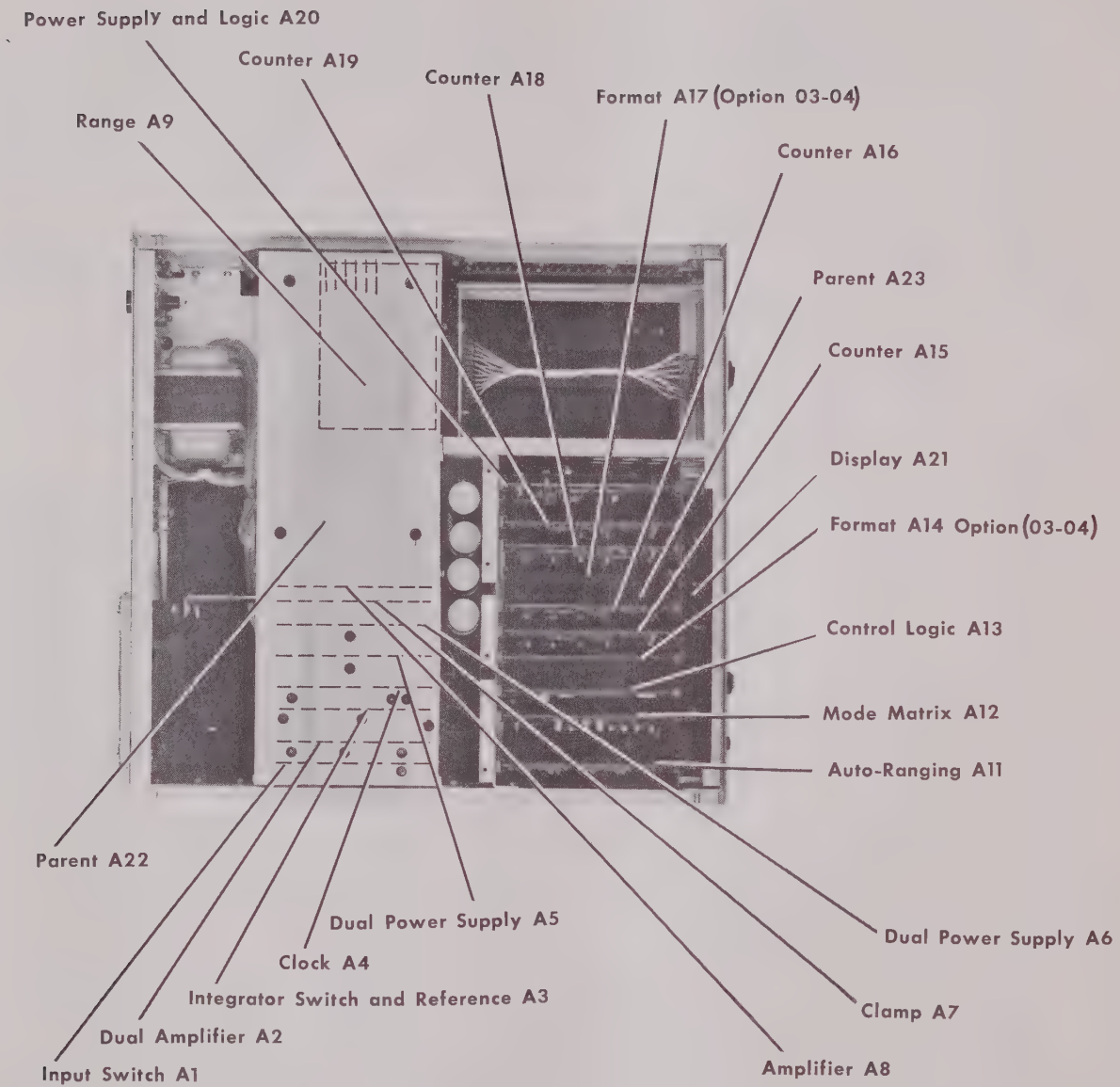


Figure 5-6. Component Location, Model 7100A

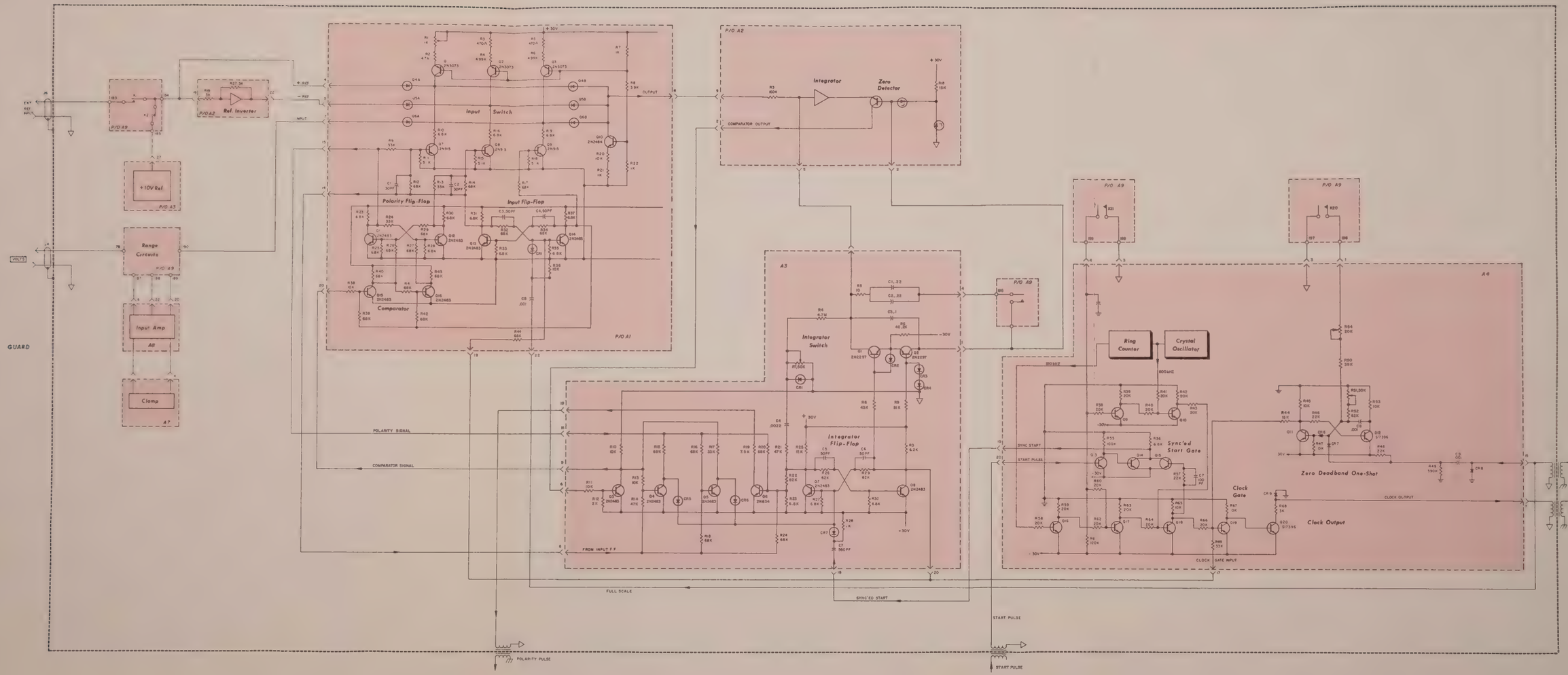


Figure 5-7. Simplified Schematic, Model 7100A

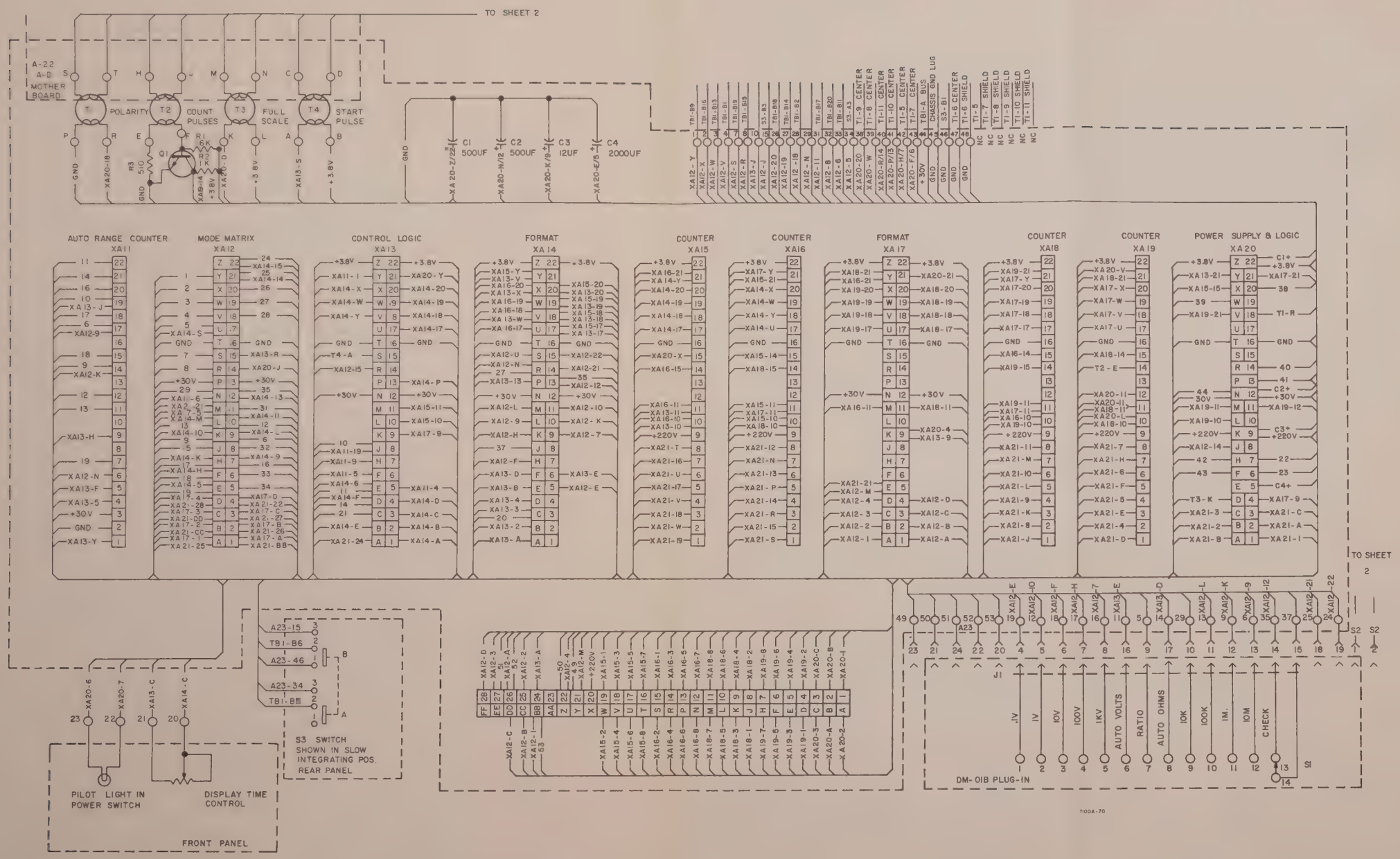


Figure 5-8. Schematic Diagram, Parent Board A22/A23 (Sheet 1 of 2)

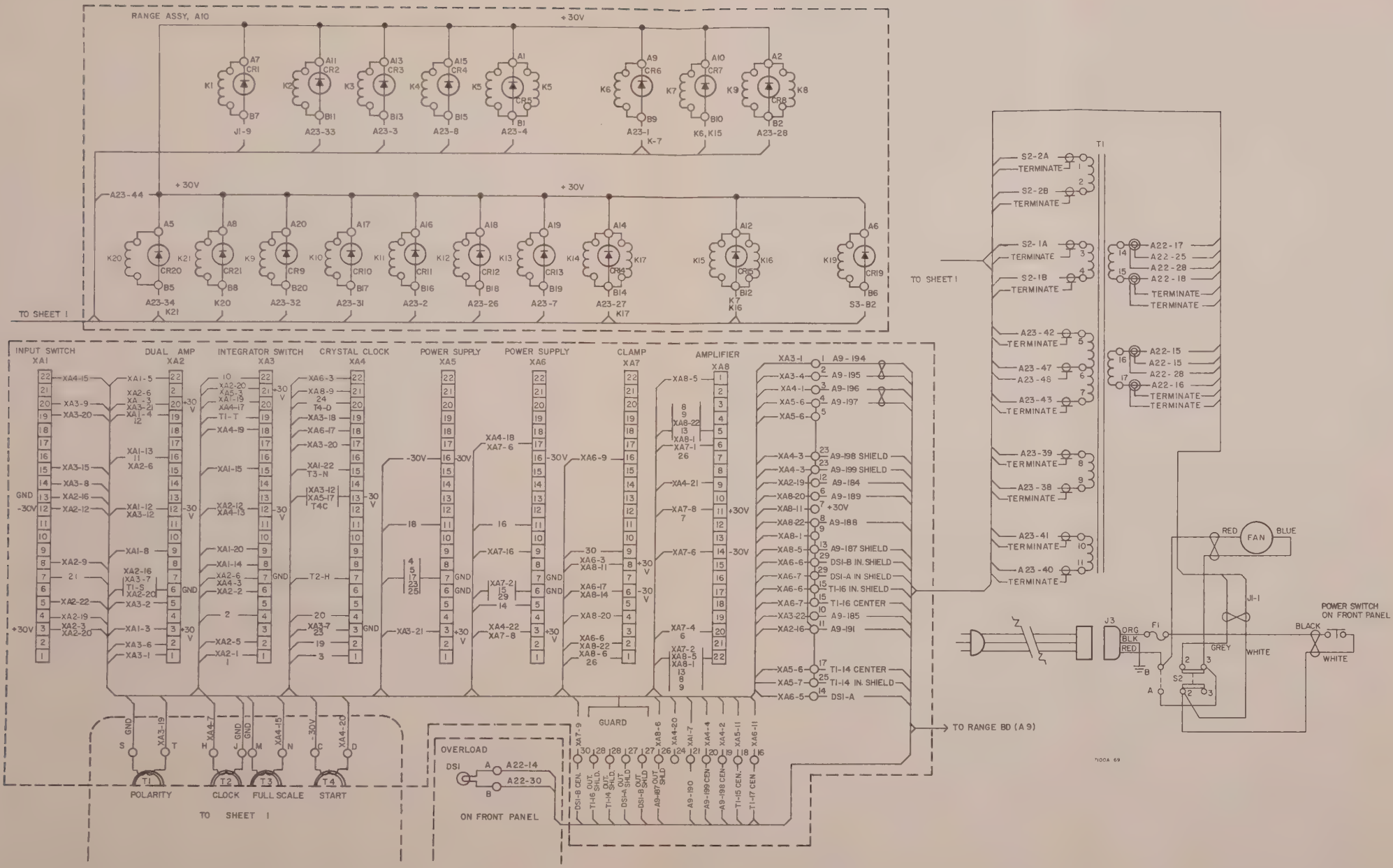


Figure 5-8. Schematic Diagram, Parent Board A22/A23 (Sheet 2 of 2)

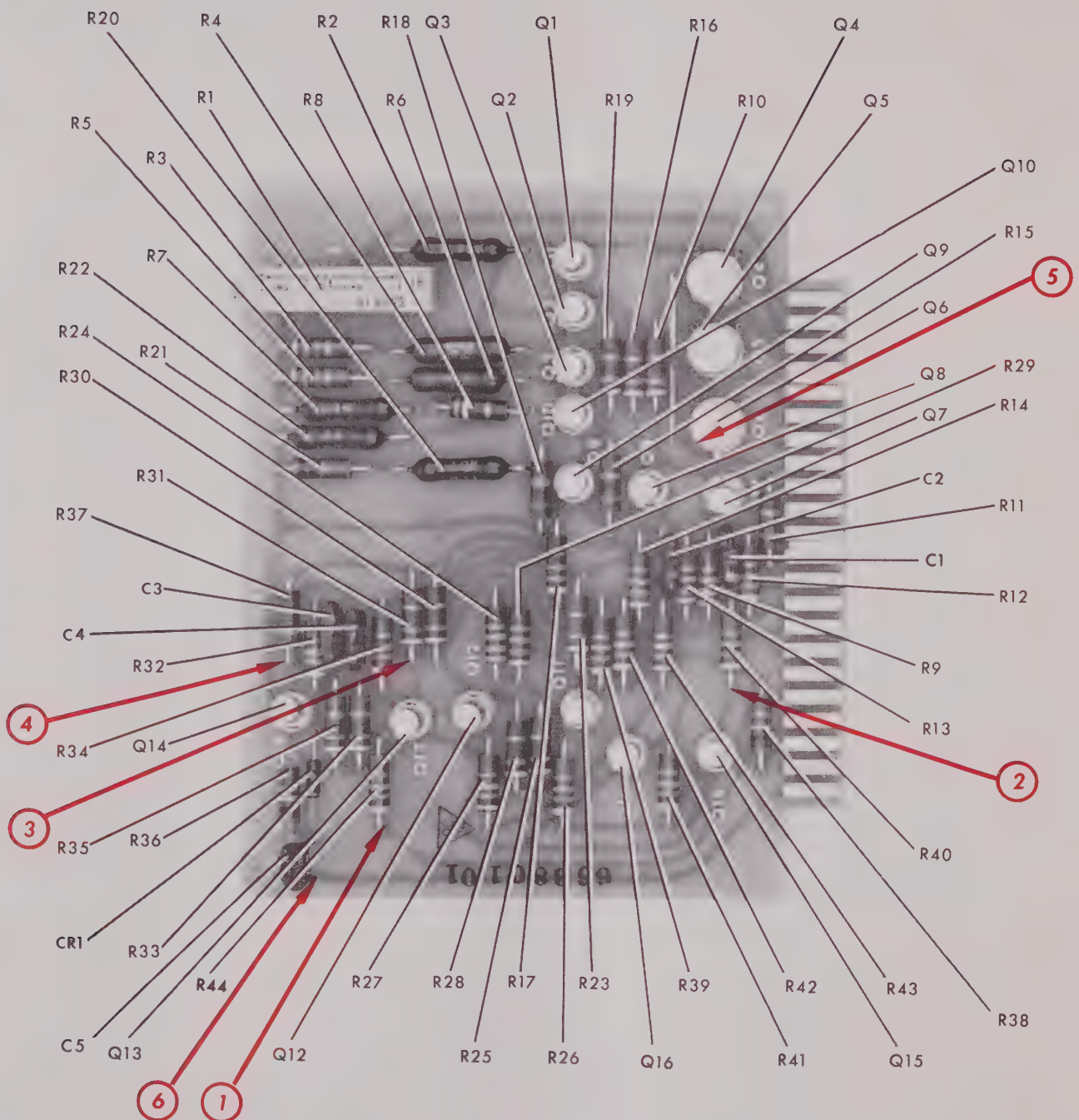


Figure 5-10. Component Location, Input Switch Assembly A1

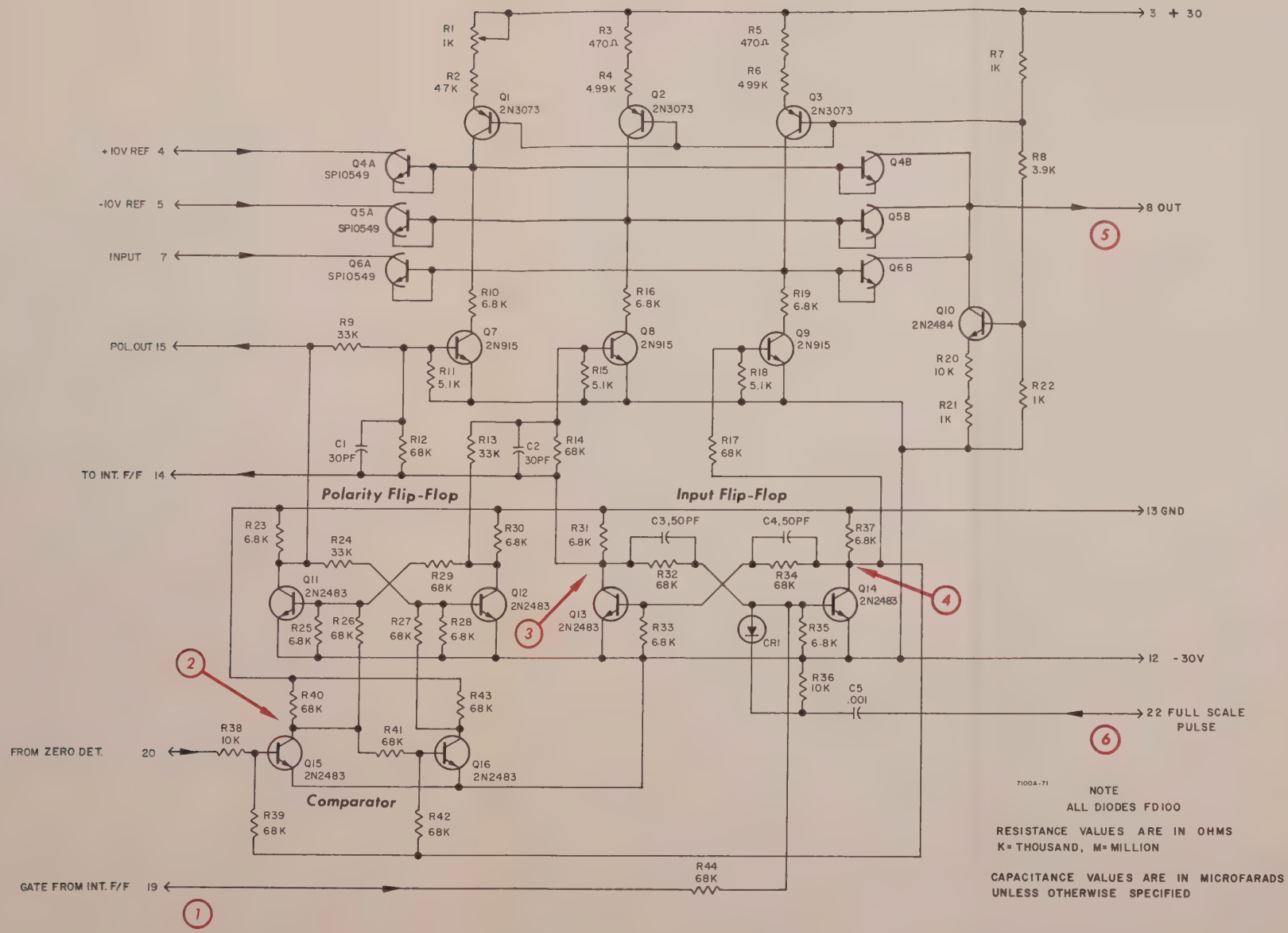


Figure 5-11. Schematic Diagram, Input Switch A1

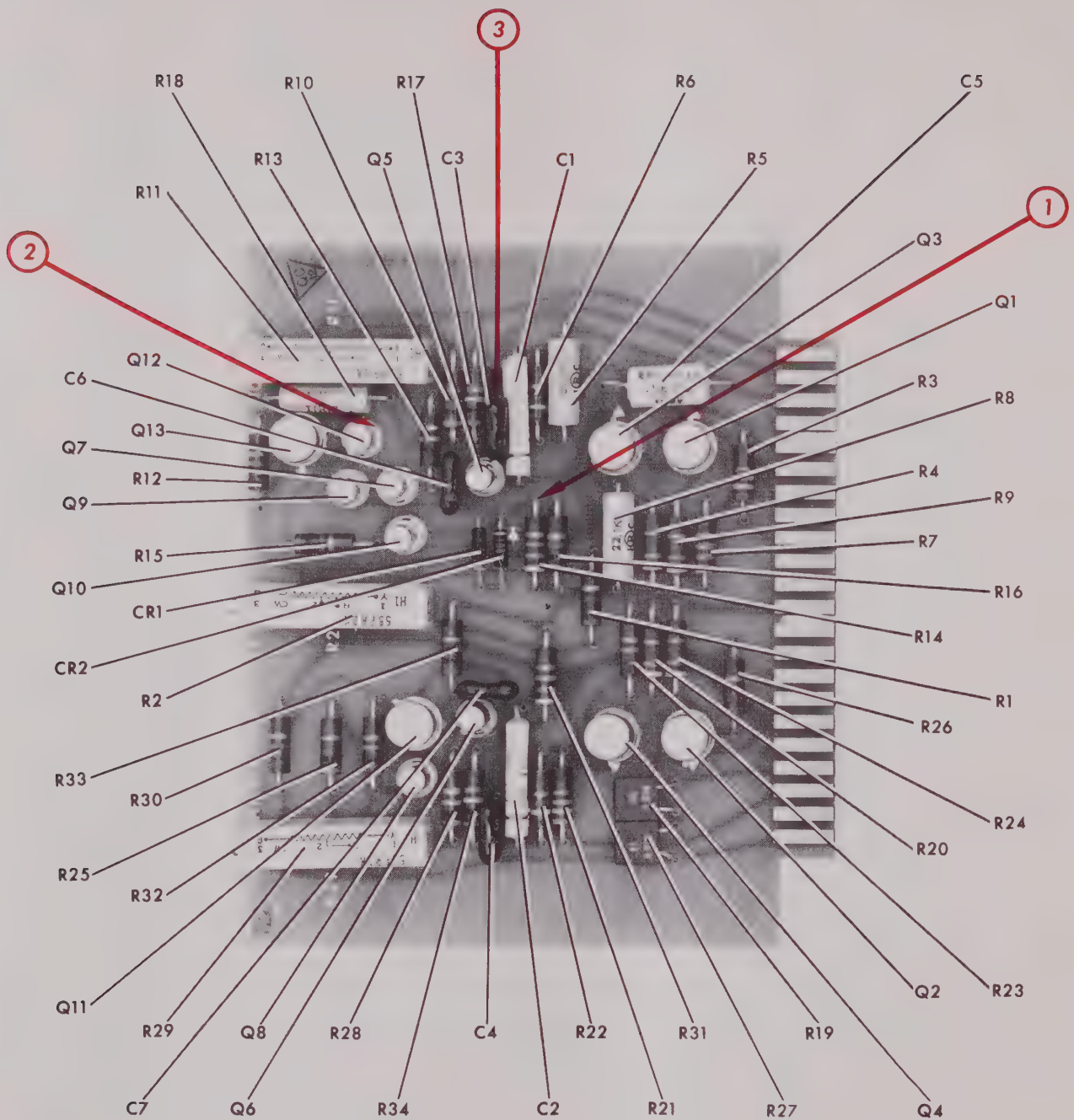
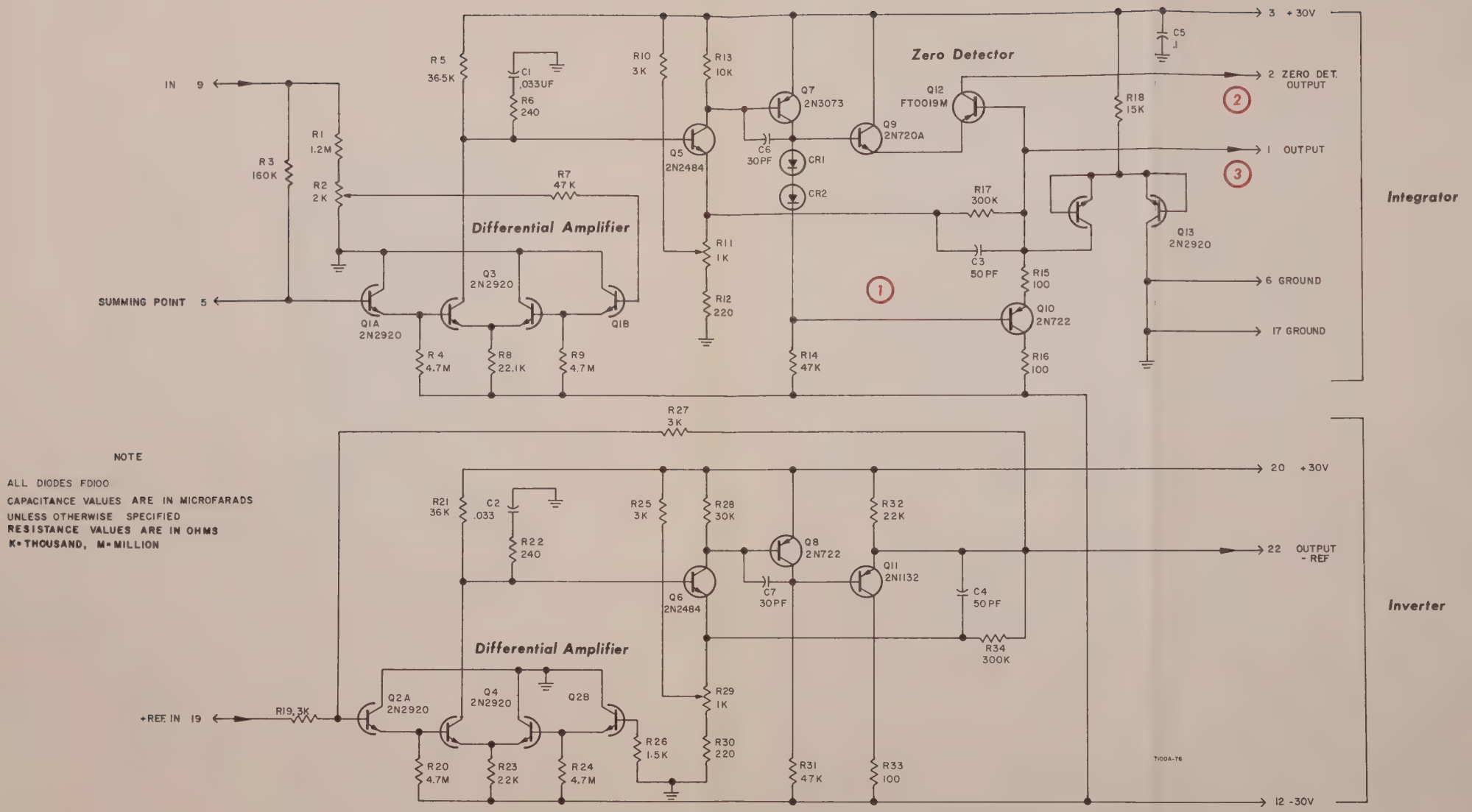


Figure 5-13. Component Location, Dual Amplifier Assembly A2



NOTE

ALL DIODES FD100
CAPACITANCE VALUES ARE IN MICROFARADS
UNLESS OTHERWISE SPECIFIED
RESISTANCE VALUES ARE IN OHMS
K=THOUSAND, M=MILLION

Figure 5-14. Schematic Diagram, Dual Amplifier A2

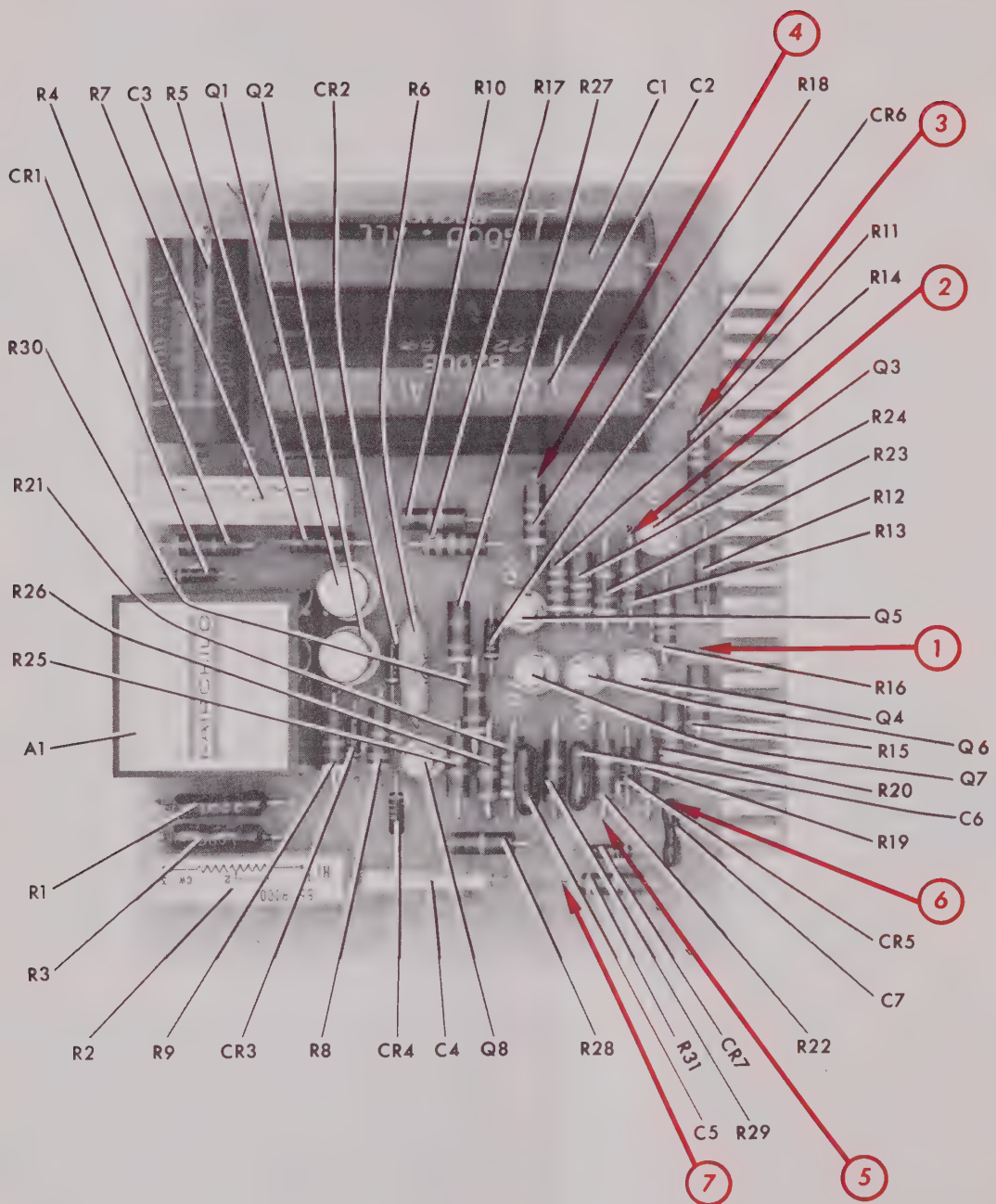
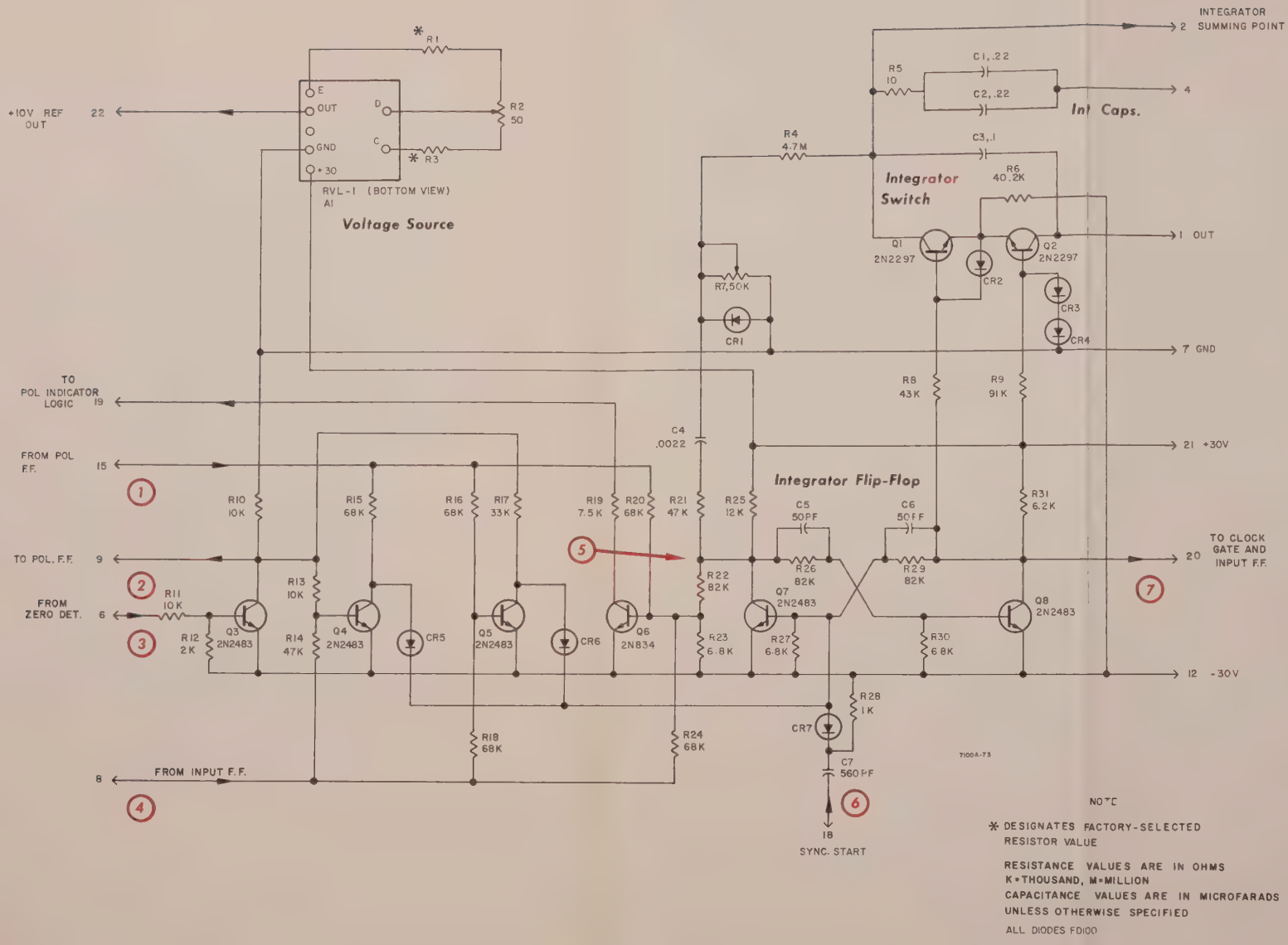


Figure 5-16. Component Location, Integrator Switch and Reference Assembly A3



NOTE

* DESIGNATES FACTORY-SELECTED RESISTOR VALUE

RESISTANCE VALUES ARE IN OHMS
K=THOUSAND, M=MILLION
CAPACITANCE VALUES ARE IN MICROFARADS
UNLESS OTHERWISE SPECIFIED

ALL DIODES FD100

Figure 5-17. Schematic, Integrator Switch and Reference A3

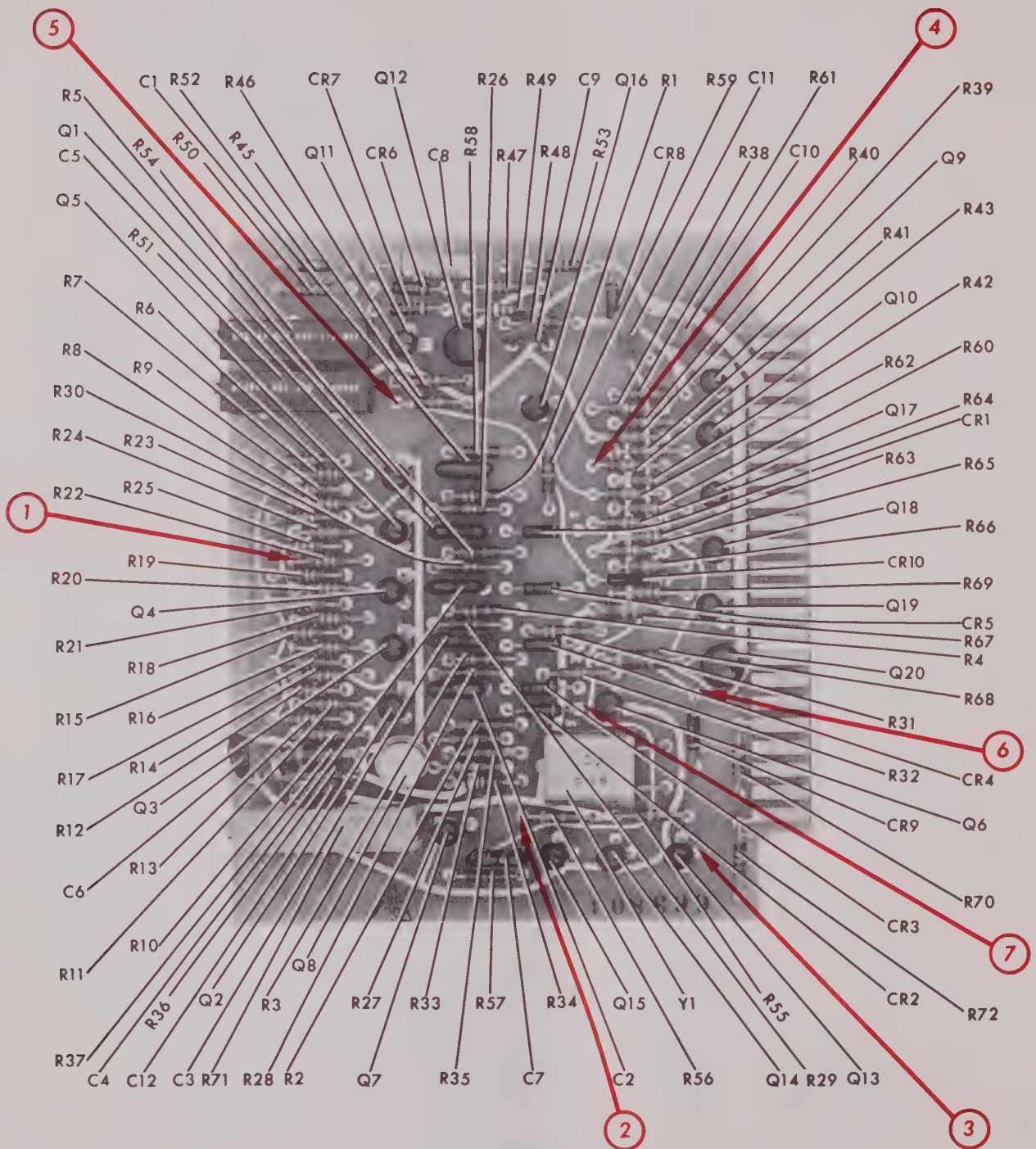


Figure 5-19. Component Location, Clock Assembly A4

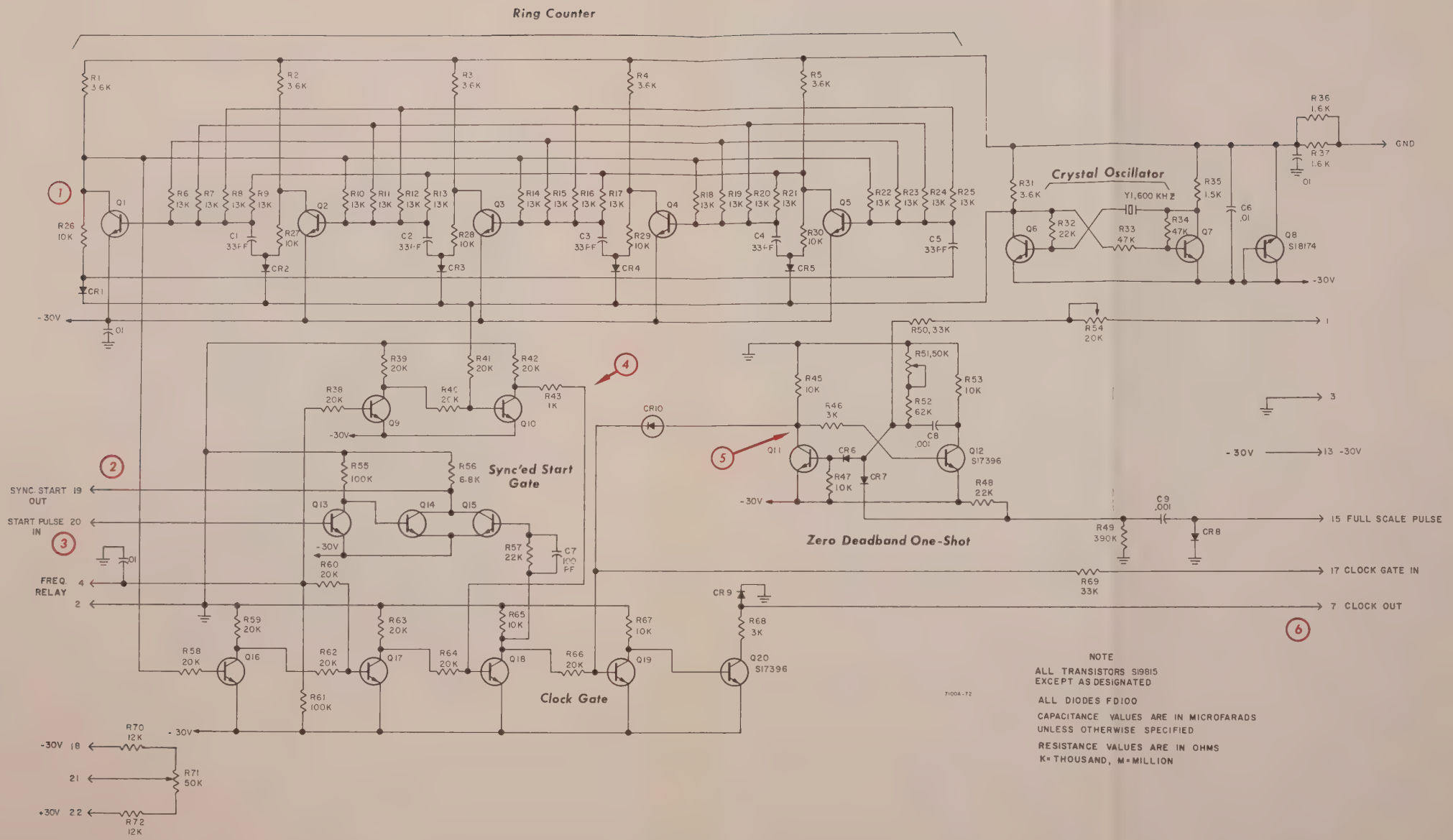


Figure 5-20. Schematic Diagram, Clock A4

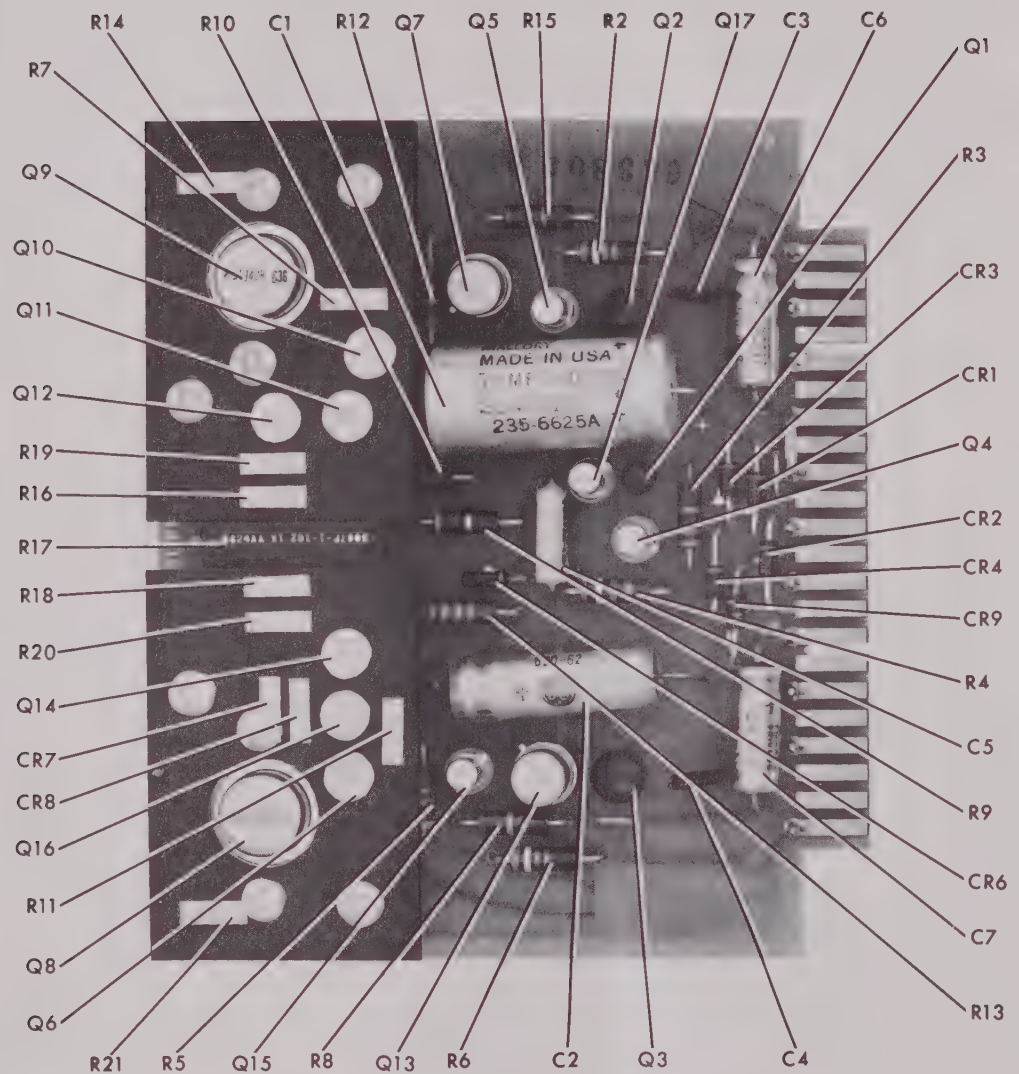
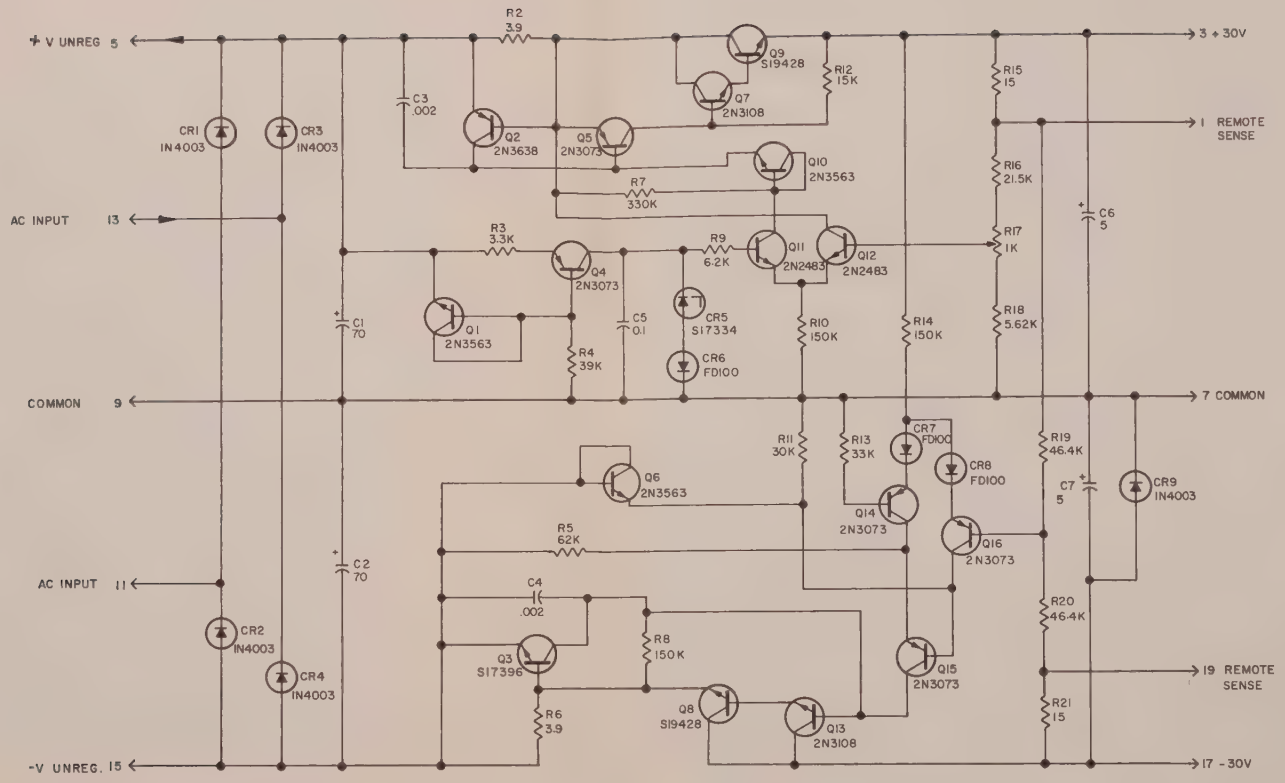


Figure 5-21. Component Location, Dual Power Supply Assembly A5, A6



NOTE

TRANSISTORS Q11 AND Q12 MATCHED PAIR

CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

RESISTANCE VALUES ARE IN OHMS
K = THOUSAND, M = MILLION

Figure 5-22. Schematic Diagram, Dual Power Supply A5, A6

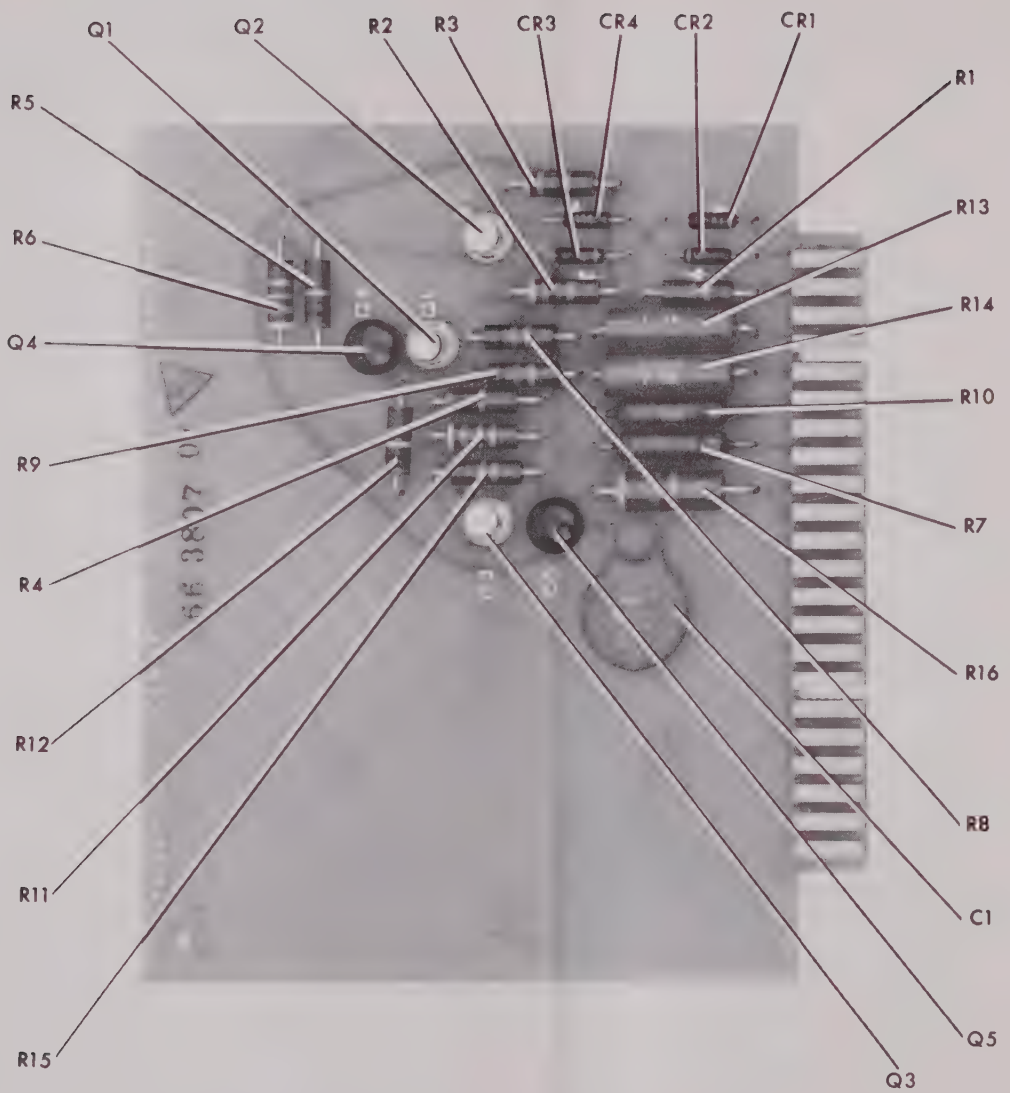
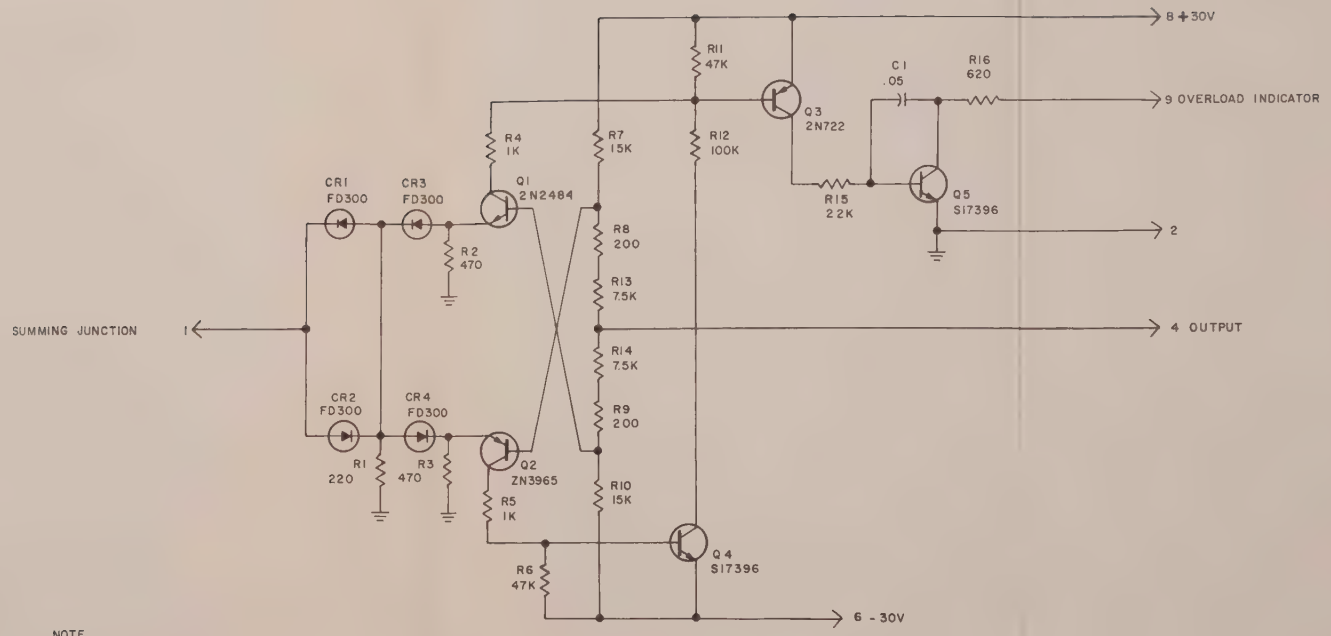


Figure 5-23. Component Location, Clamp Assembly A7



NOTE

CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

RESISTANCE VALUES ARE IN OHMS
K= THOUSAND, M=MILLION

Figure 5-24. Schematic Diagram, Clamp A7

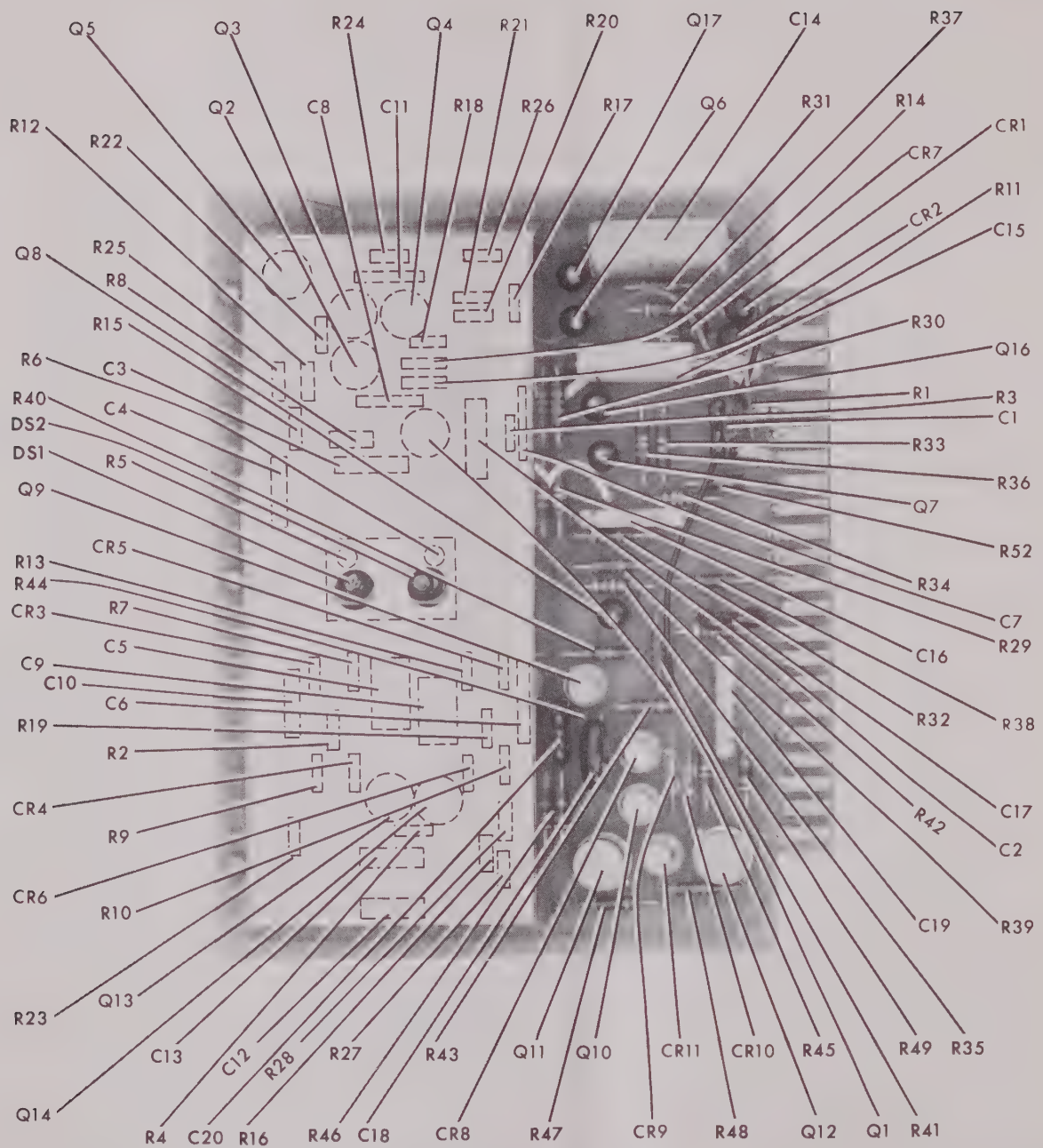


Figure 5-25. Component Location, Amplifier Assembly A8

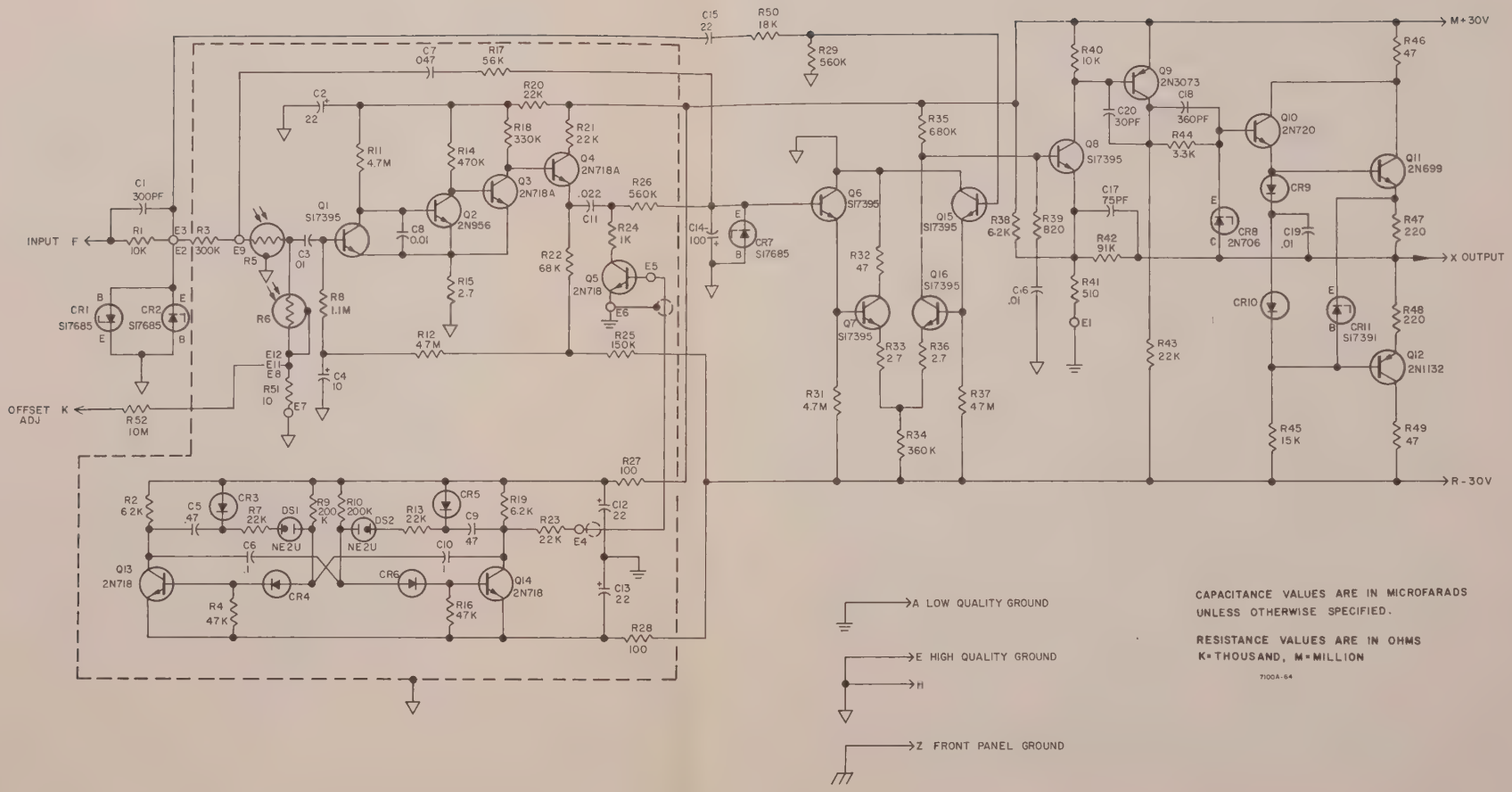


Figure5-26. Schematic Diagram, Amplifier A8

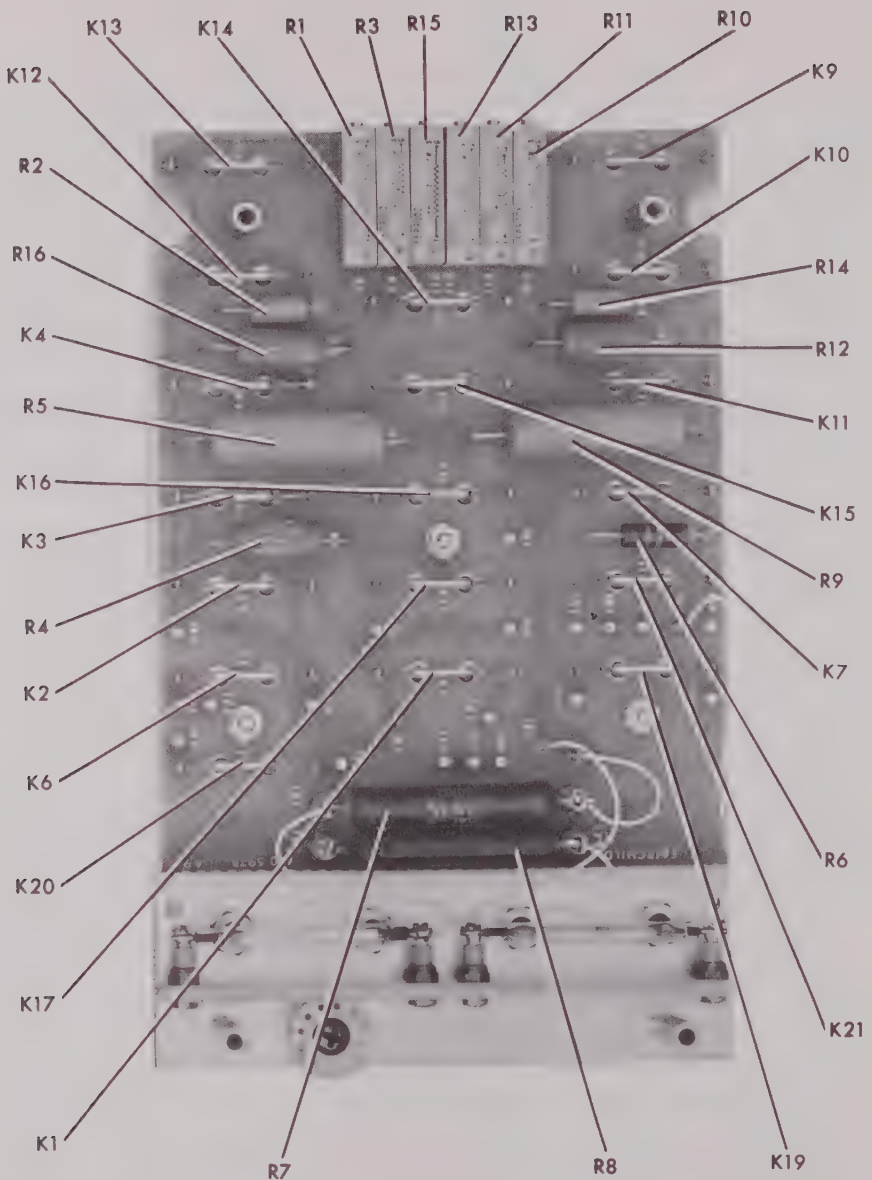
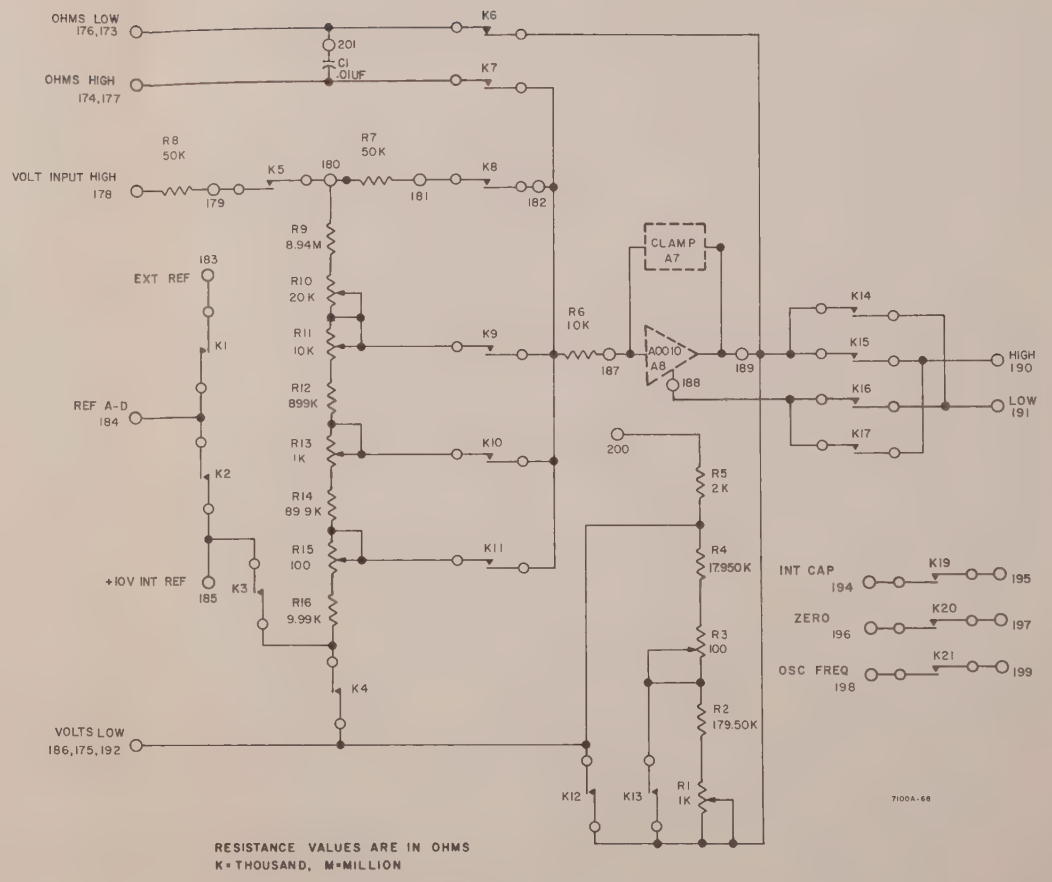


Figure 5-27. Component Location, Range Assembly A9

	CHECK	10MΩ	1MΩ	100KΩ	10KΩ	E1/E2	1000V	100V	10V	1V	.1V	ACV	LOWΩ	
											X			.XXXXX
						X				X				X.XXX
					X				X					XX.XXX
				X				X						XXX.XX
			X				X							XXXX.X
						X								K1
	X	X	X	X	X		X	X	X	X	X	X	X	K2
	X	X	X	X	X									K3
							X	X						K4
						X	X	X	X	X	X	X	X	K5
		X	X	X	X									K6
		X	X	X	X									K7
		X				X			X	X	X	X	X	K8
			X					X						K9
	X			X			X							K10
					X									K11
	X					X	X	X	X					K12
										X		X	X	K13
	X					X	X	X	X	X	X	X	X	K14
		X	X	X	X									K15
		X	X	X	X									K16
	X					X	X	X	X	X	X	X	X	K17
														K18
											X	X	X	K19
	X	X	X	X	X	X	X	X	X	X				K20
	X	X	X	X	X	X	X	X	X	X				K21
							X	X	X	X	X			V
		X	X	X	X								X	Ω
						X								E1/E2
												X		ACV
	X	X	X	X	X							X	X	POL BLANK



RESISTANCE VALUES ARE IN OHMS
K = THOUSAND, M = MILLION

Figure 5-28. Schematic Diagram, Range Circuit A9

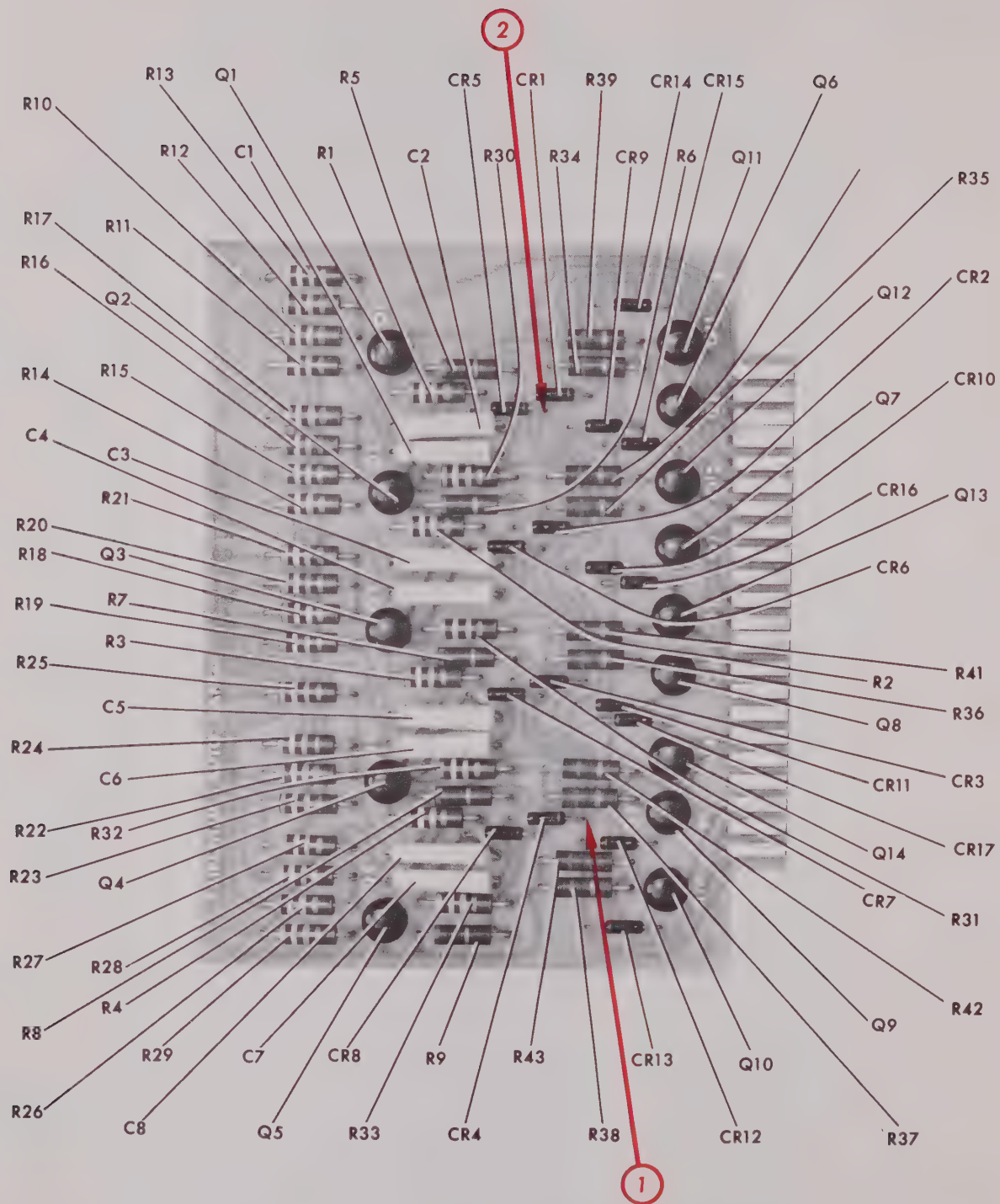
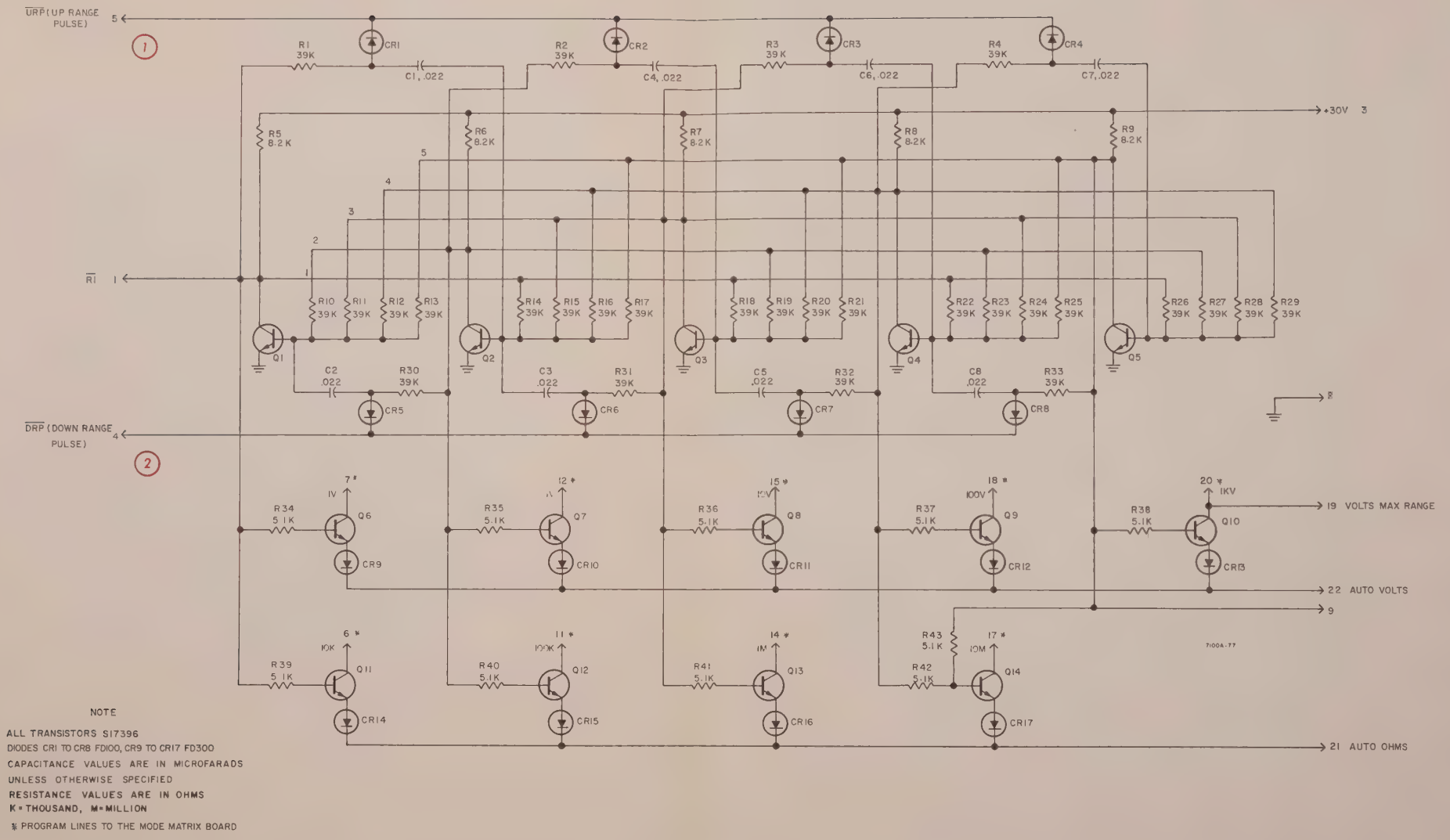


Figure 5-30. Component Location, Auto Ranging Assembly A11



NOTE

ALL TRANSISTORS S17396
DIODES CR1 TO CR8 FD100, CR9 TO CR17 FD300
CAPACITANCE VALUES ARE IN MICROFARADS
UNLESS OTHERWISE SPECIFIED
RESISTANCE VALUES ARE IN OHMS
K = THOUSAND, M = MILLION
* PROGRAM LINES TO THE MODE MATRIX BOARD

Figure 5-31. Schematic Diagram, Auto Ranging All

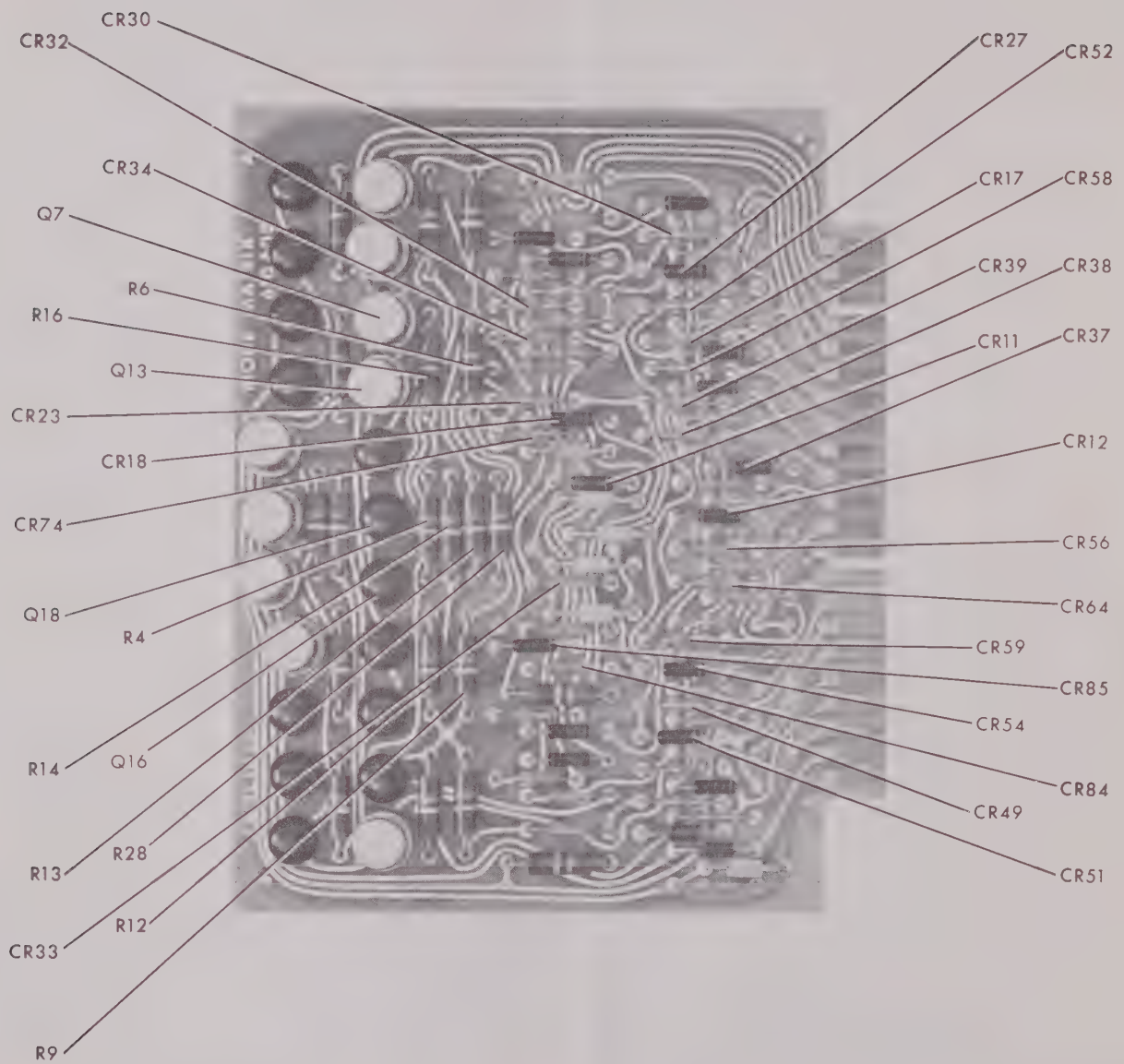
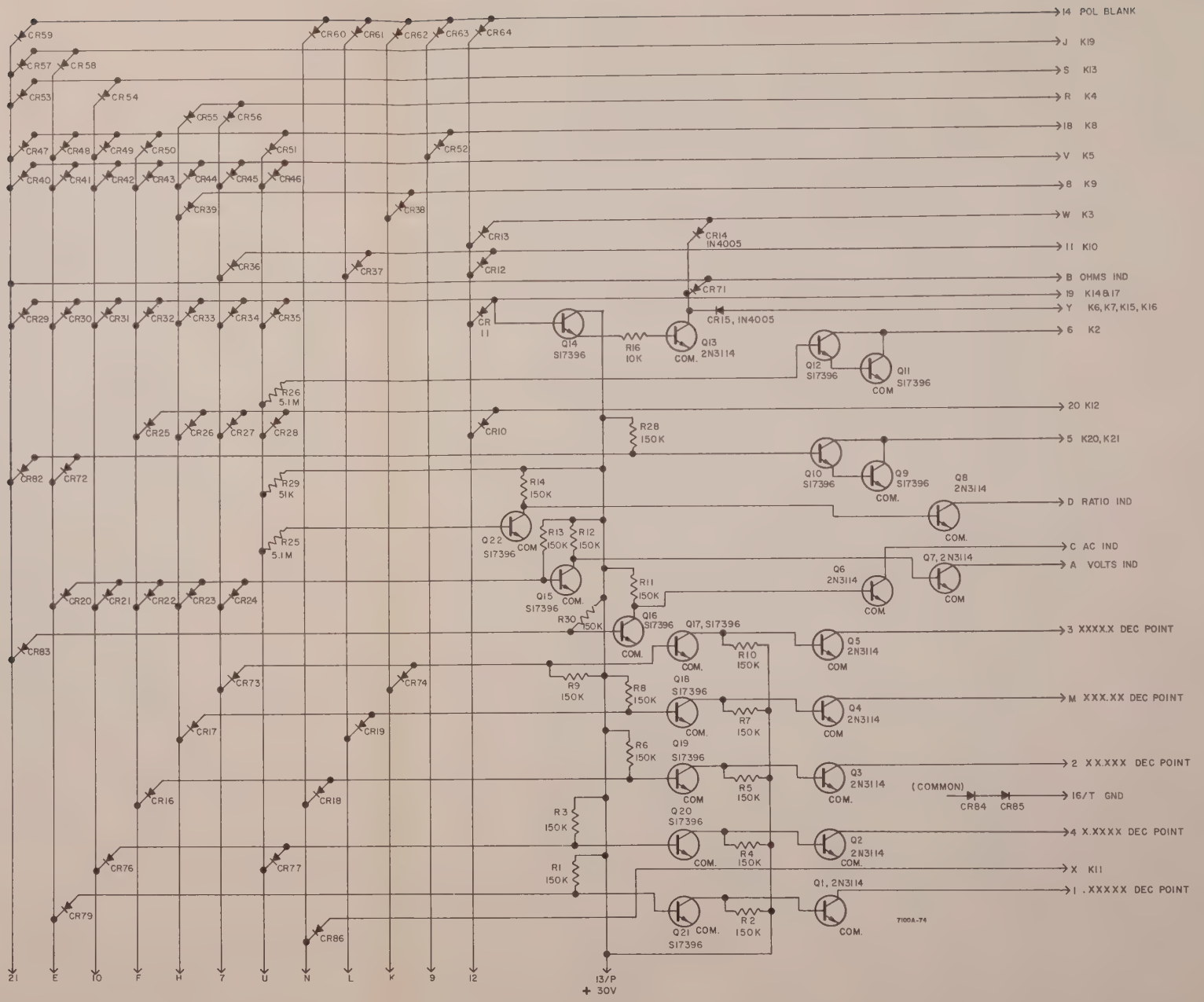


Figure 5-32. Component Location, Mode Matrix Assembly A12 (Cont.)



NOTE

ALL DIODES FD 100 UNLESS OTHERWISE INDICATED

CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

RESISTANCE VALUES ARE IN OHMS K = THOUSAND, M = MILLION

Figure 5-33. Schematic Diagram, Mode Matrix A12

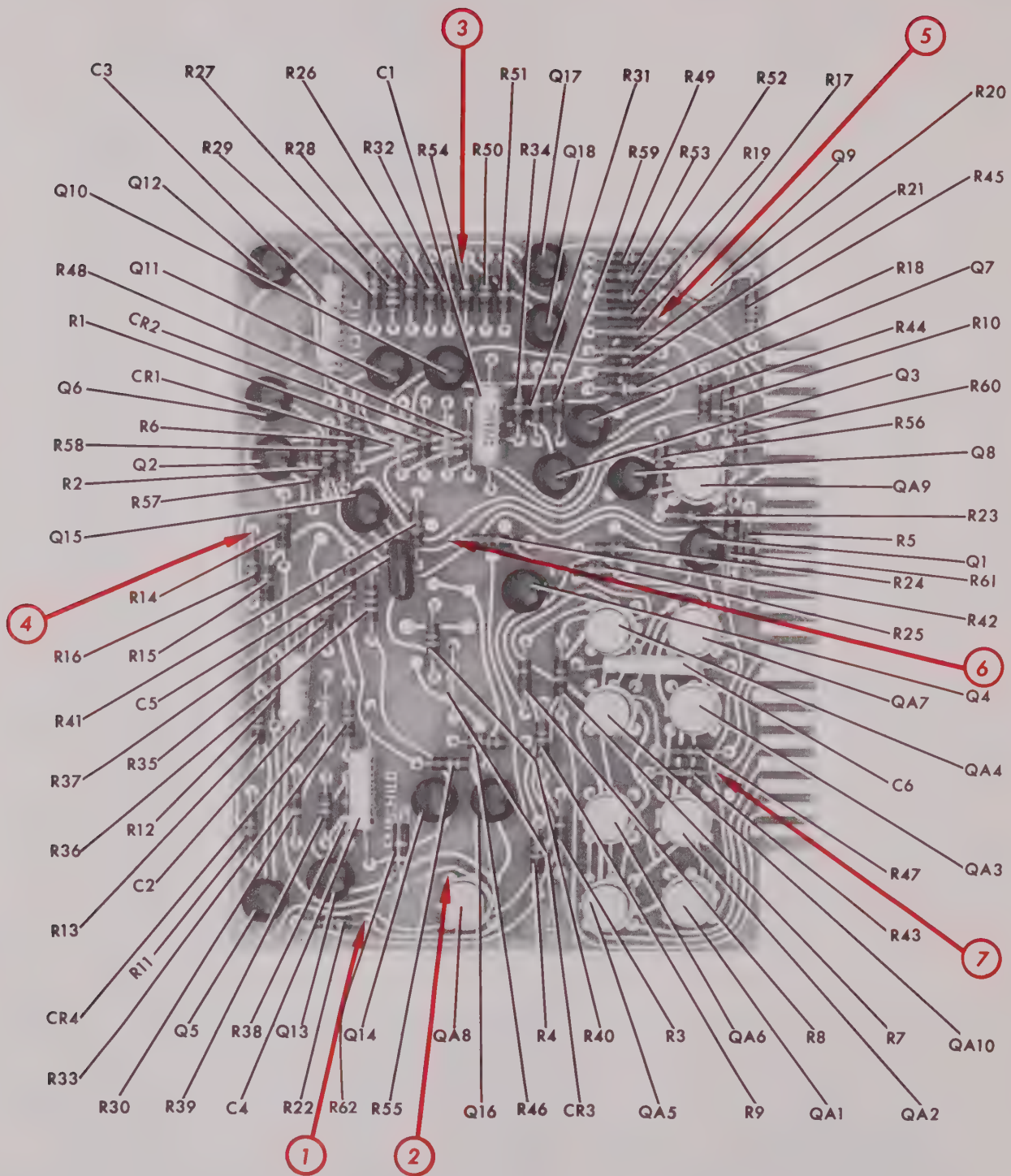
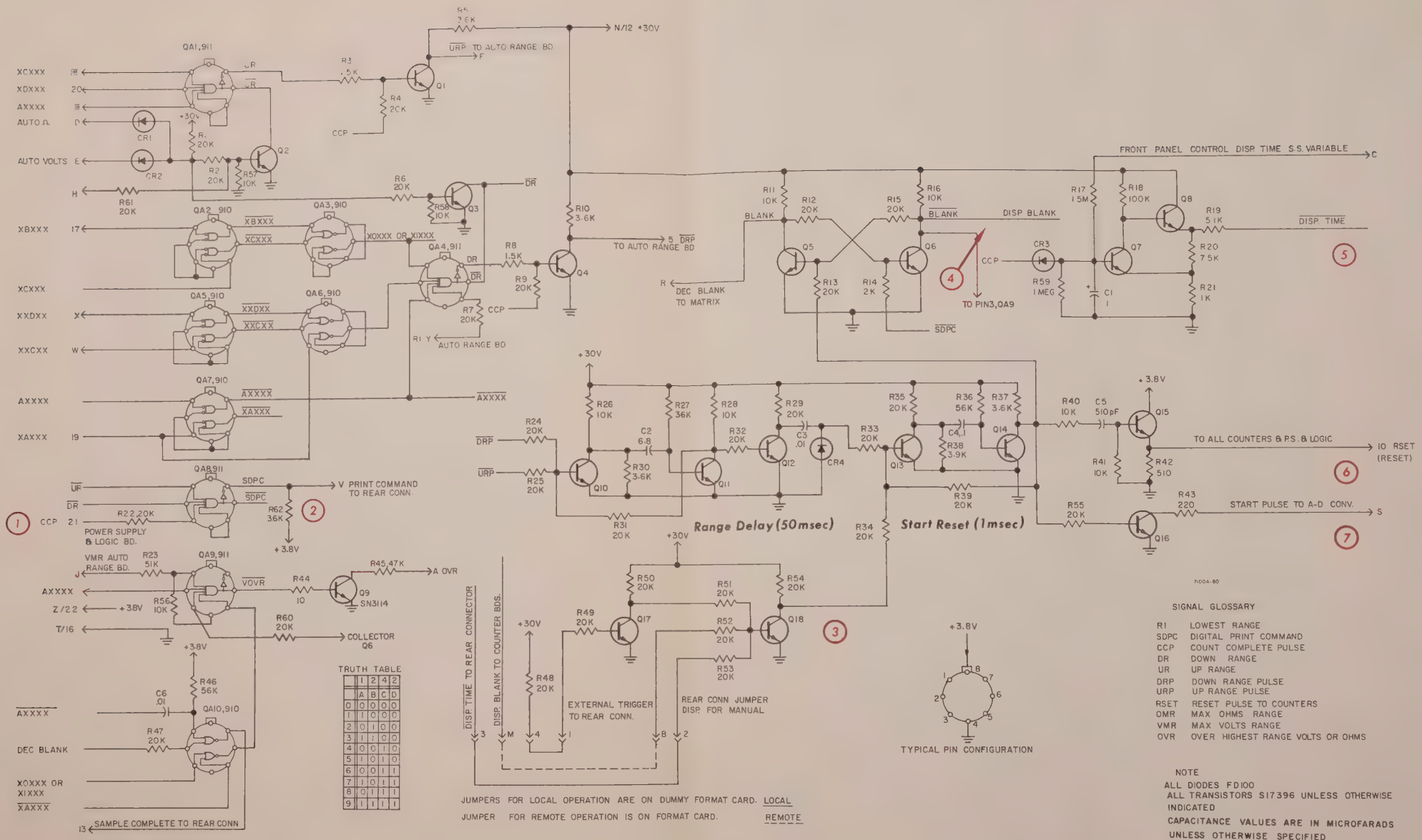


Figure 5-35. Component Location, Control Logic Assembly A13



	I	2	4	2
	A	B	C	D
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1

Figure 5-36. Schematic Diagram, Control Logic A13

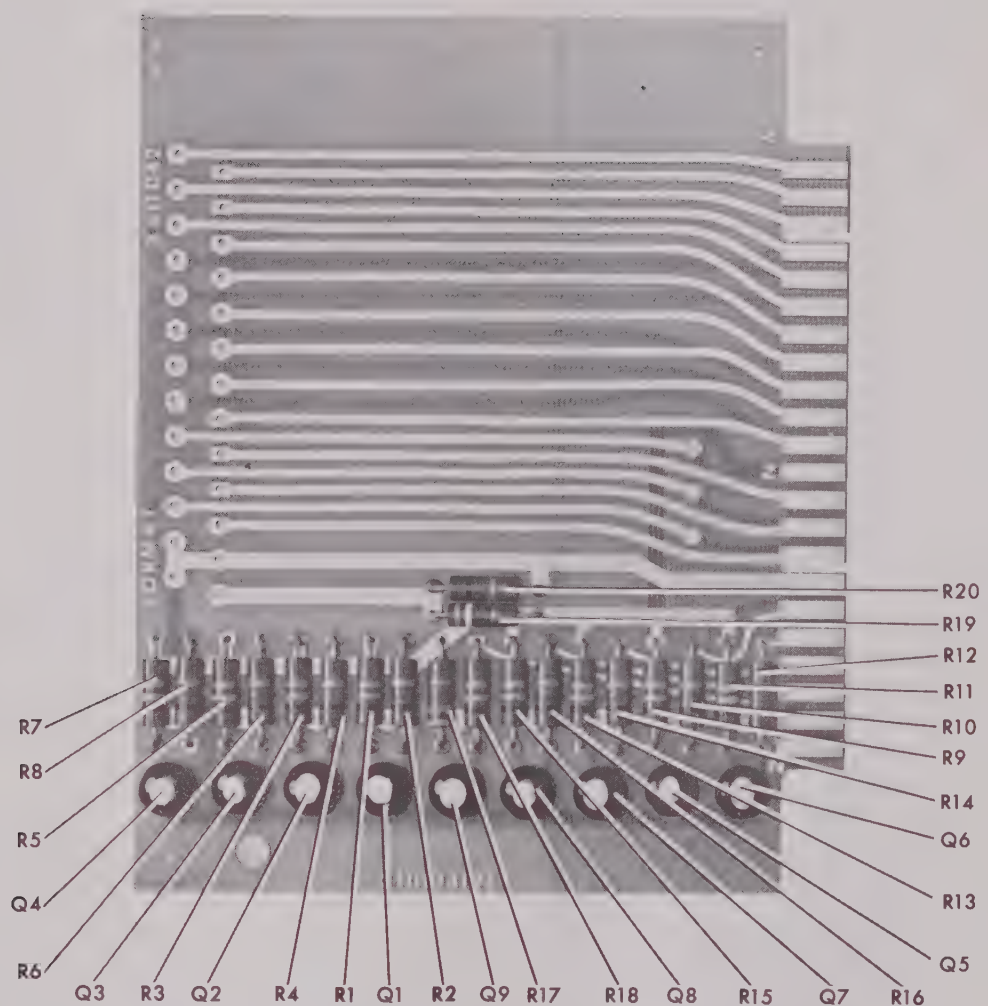
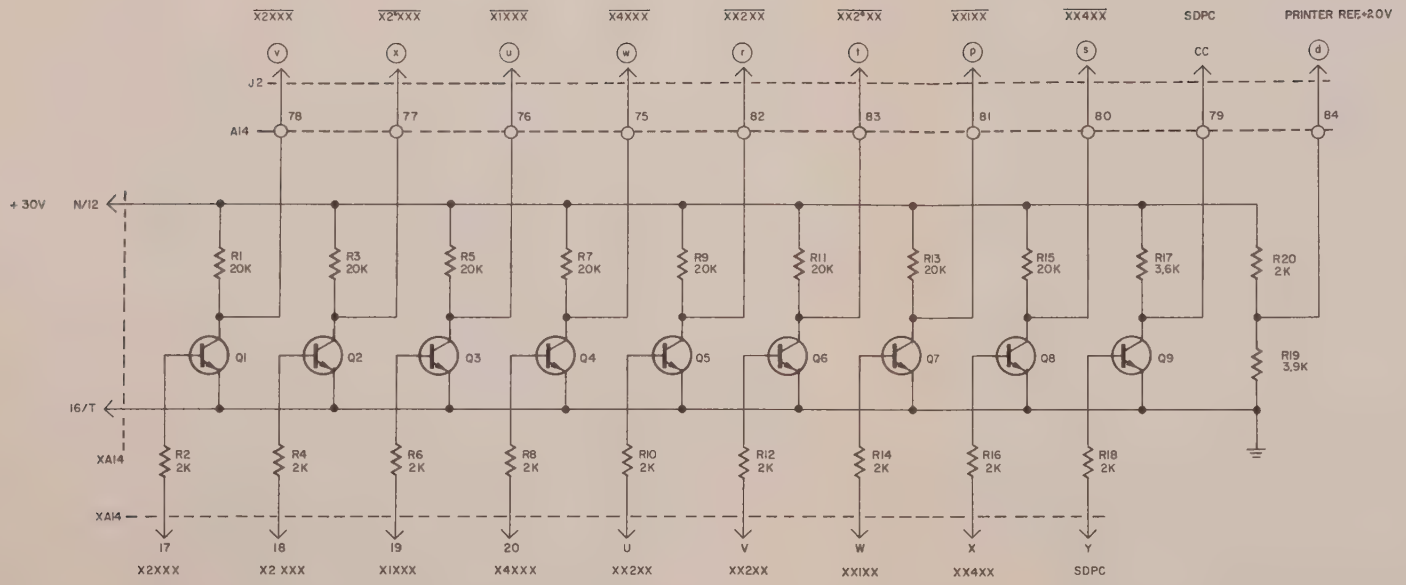


Figure 5-37. Component Location, 1-2-2'-4 Format Assembly A14 (Option 03)



NOTE

ALL TRANSISTORS S17396

CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED

RESISTANCE VALUES ARE IN OHMS
K= THOUSAND, M= MILLION

(a) DENOTES LOWER CASE LETTER ON CONNECTOR J2

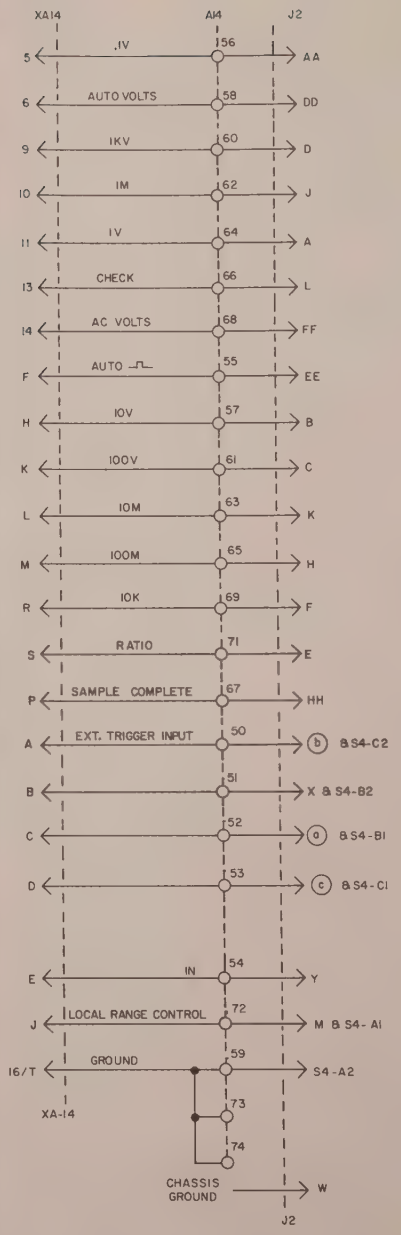


Figure 5-38. Schematic Diagram, 1-2-2'4 Format A14 (Option 03)

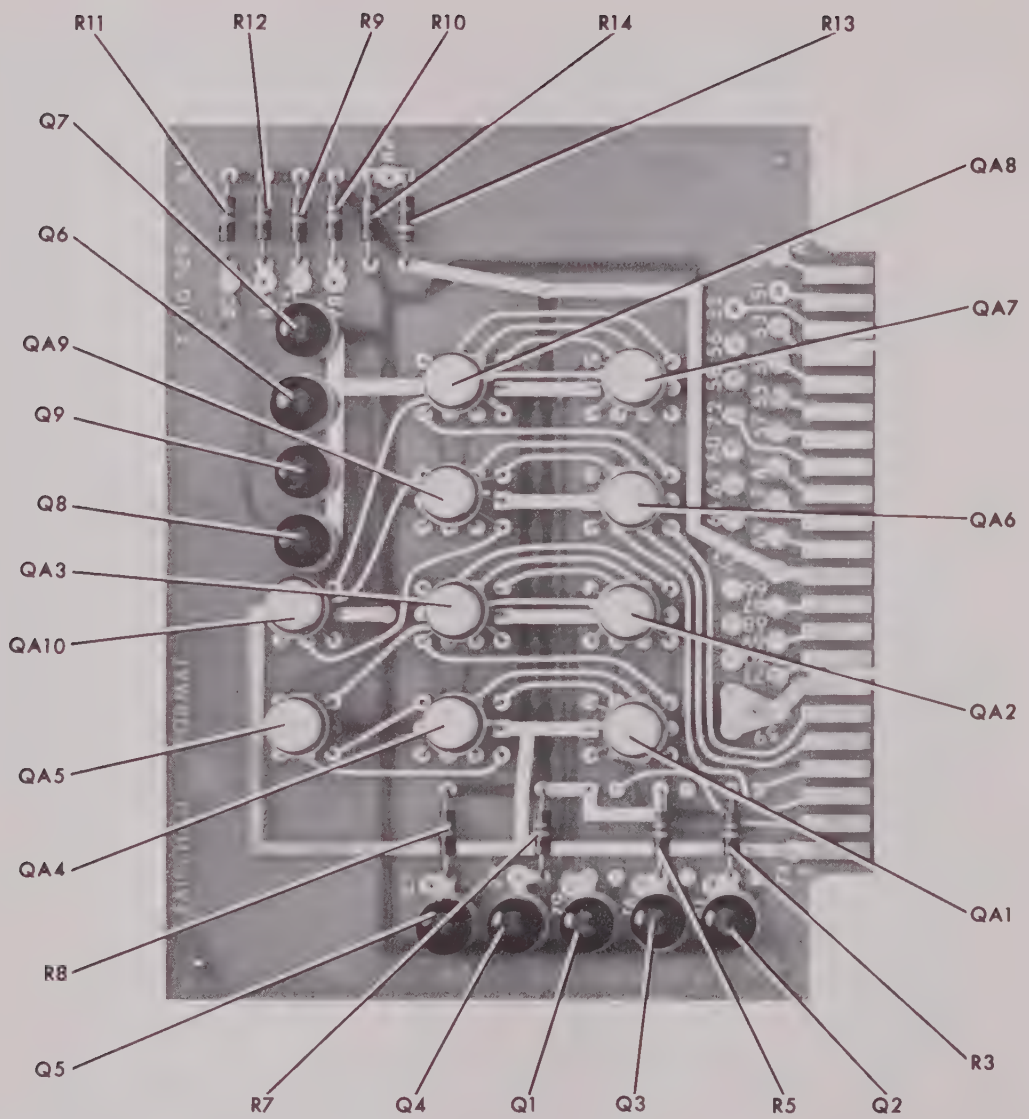


Figure 5-39. Component Location, 1-2-4-8 Format Assembly A14 (Option 04)

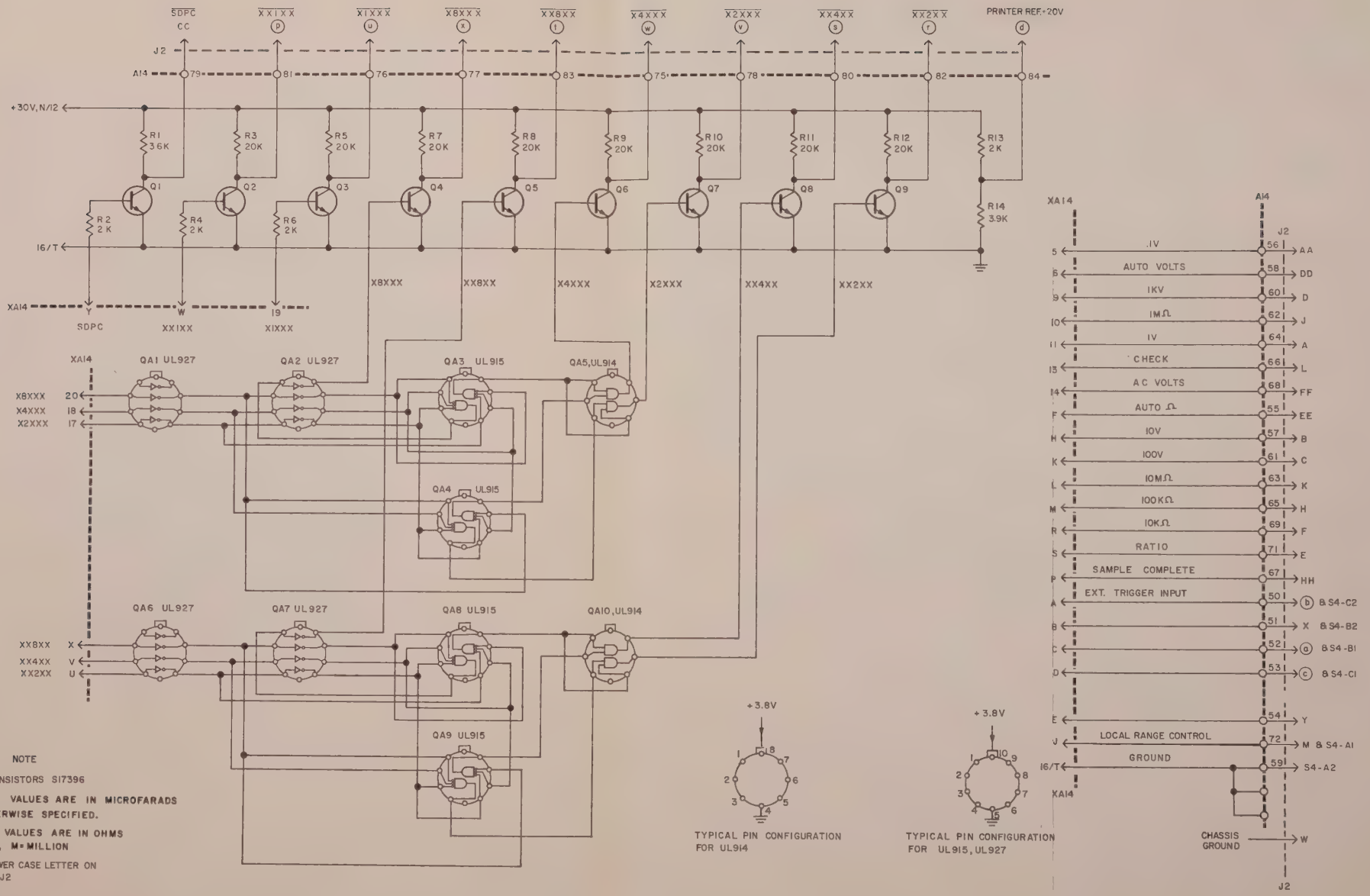


Figure 5-40. Schematic Diagram, 1-2-4-8 Format Assembly A14 (Option 04)

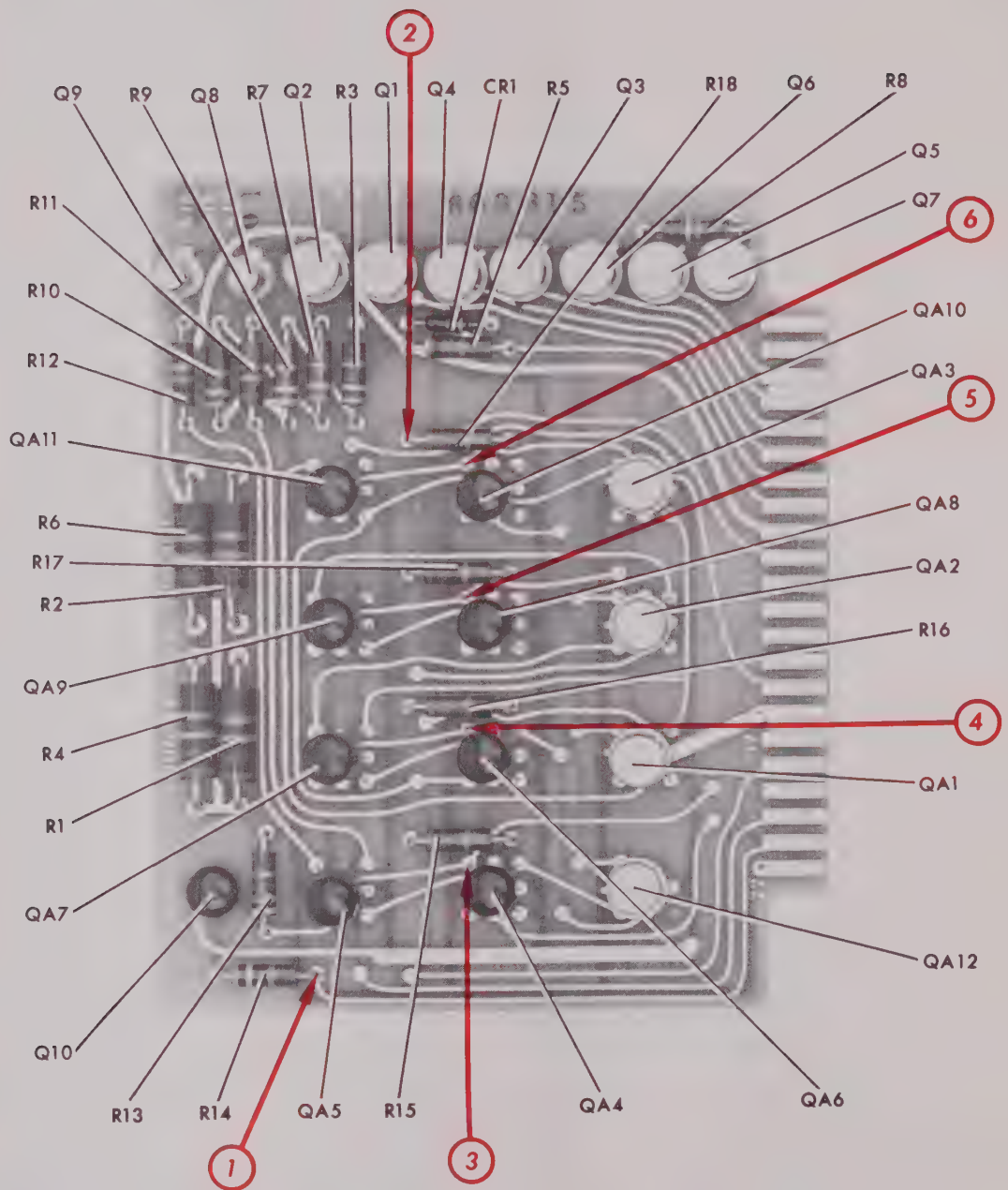
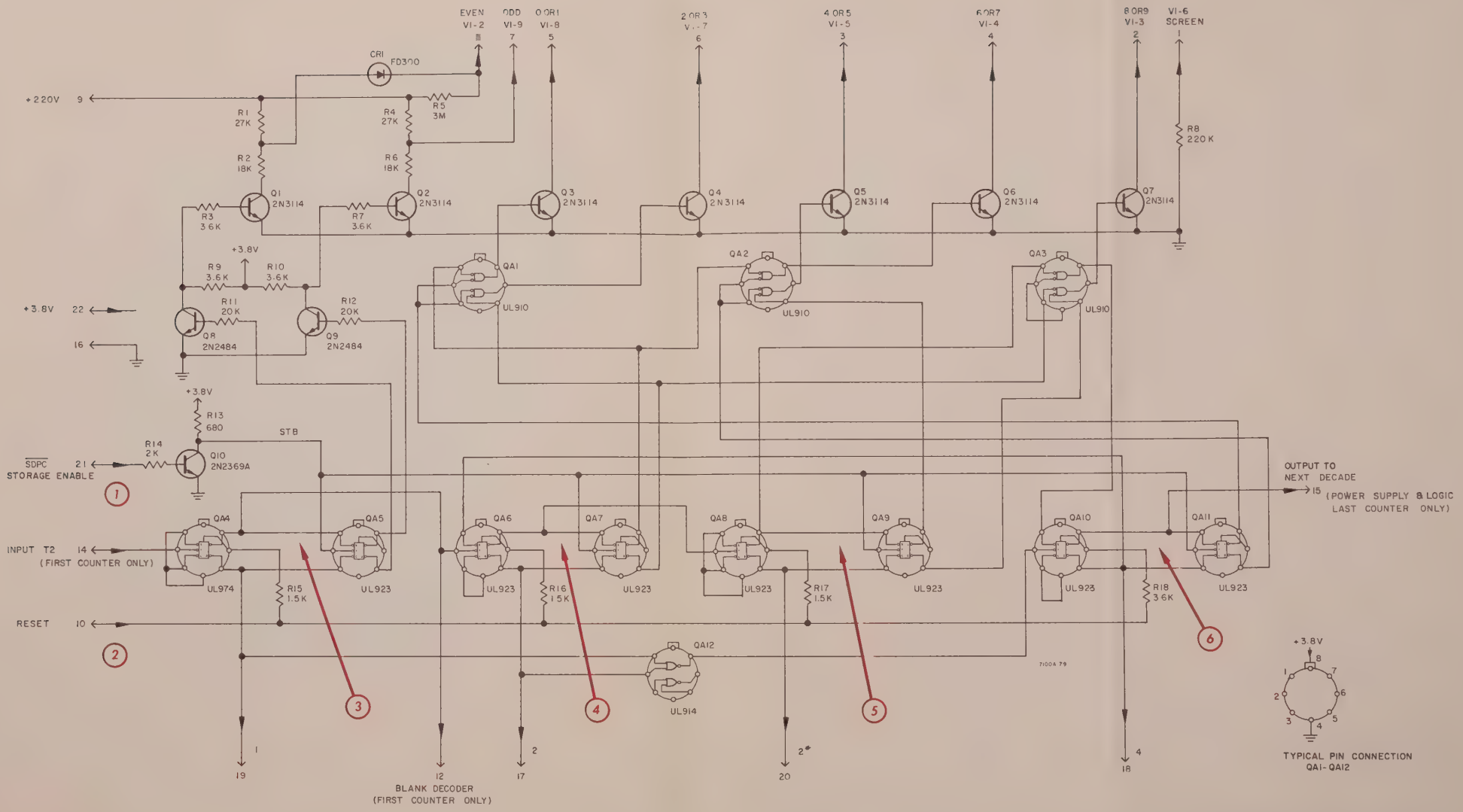


Figure 5-42. Component Location, Counter Assembly A15, 16,18,19



CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED

RESISTANCE VALUES ARE IN OHMS
K = THOUSAND, M = MILLION

Figure 5-43. Schematic Diagram, Counter A15, 16, 18, 19

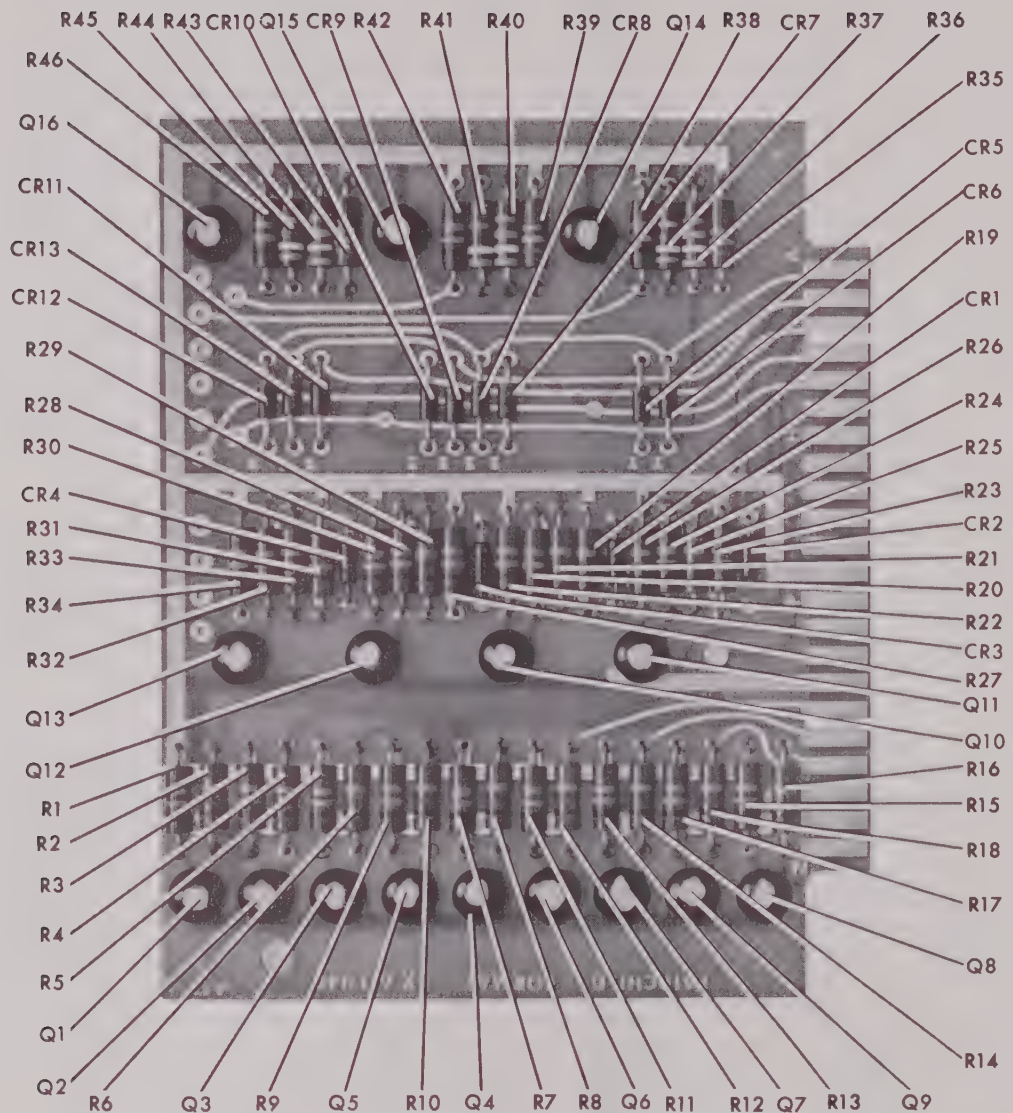


Figure 5-44. Component Location, 1-2-2'-4 Format Assembly A17(Option 03)

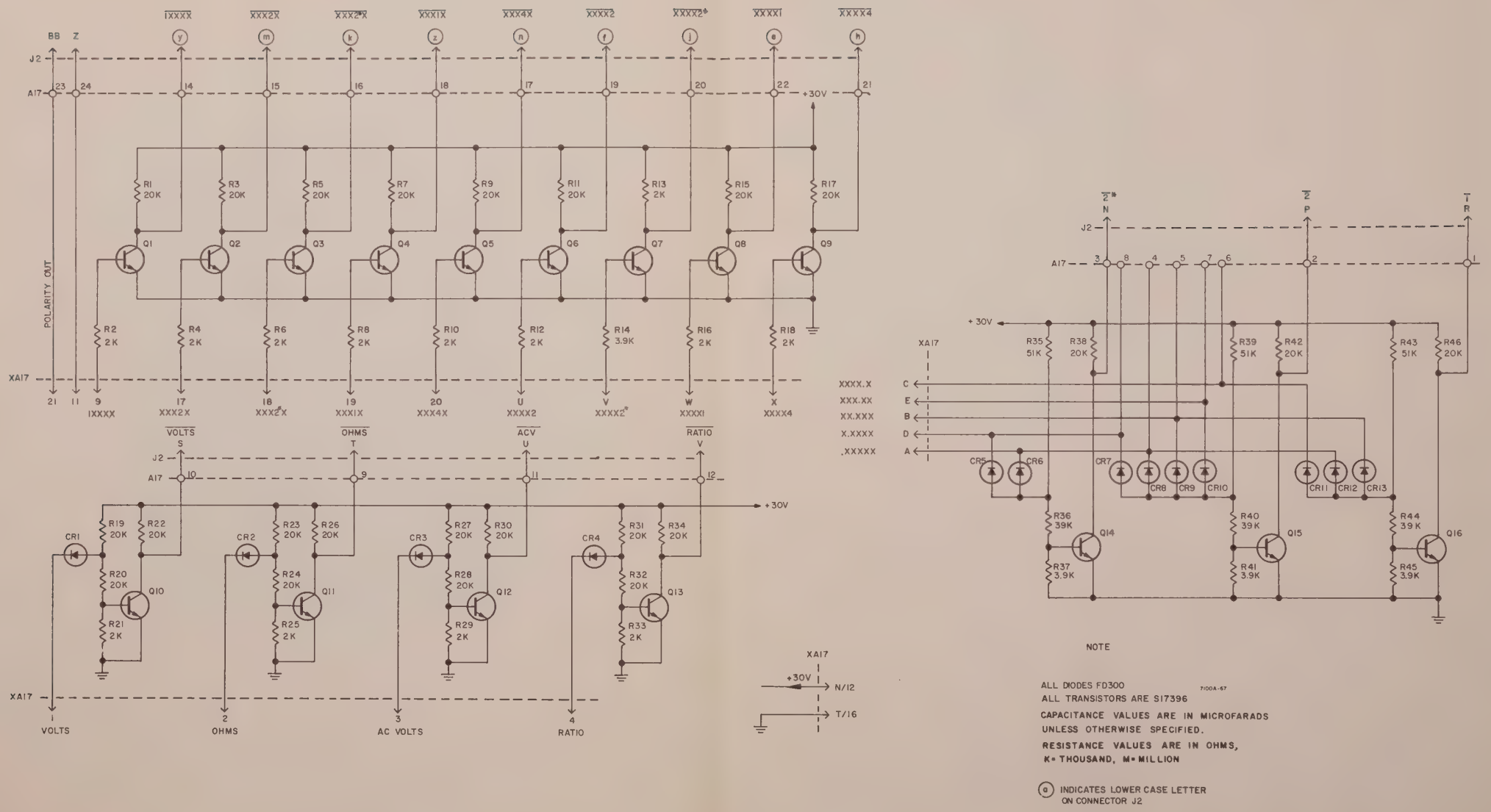


Figure 5-45. Schematic Diagram, 1-2-2'-4 Format Assembly A17 (Option 03)

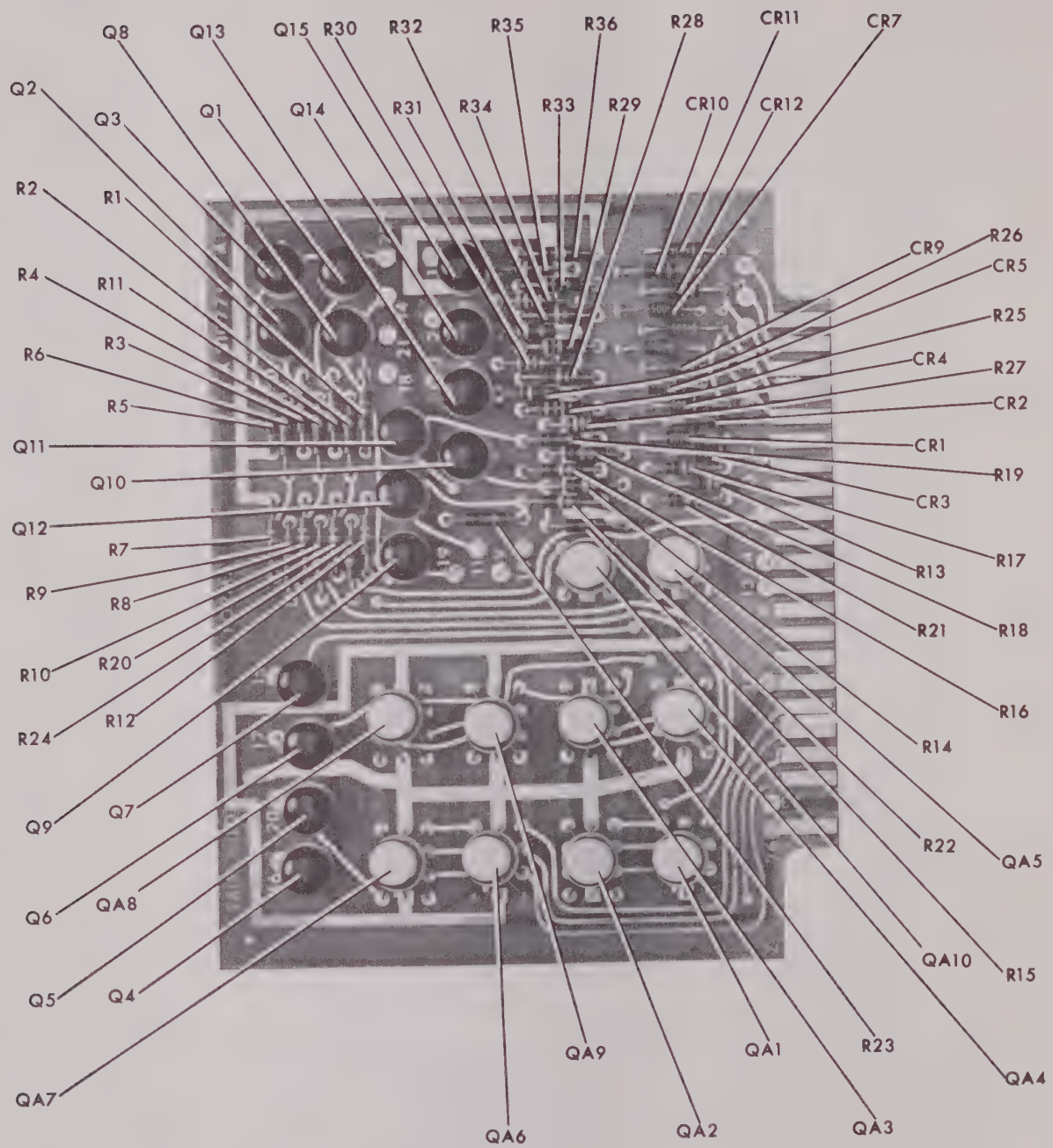
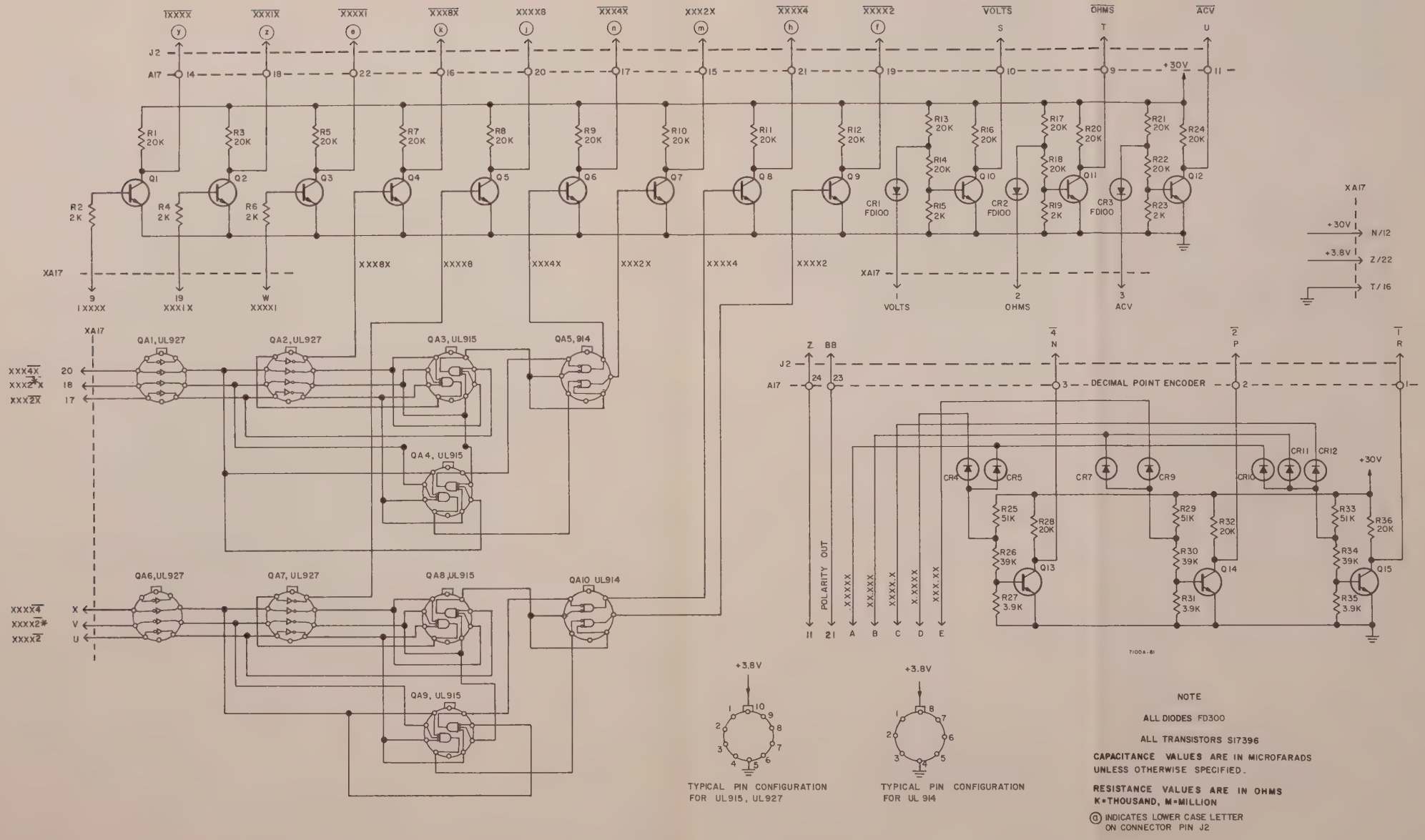


Figure 5-46. Component Location, 1-2-4-8 Format Assembly A17 (Option 04)



TYPICAL PIN CONFIGURATION FOR UL915, UL927

TYPICAL PIN CONFIGURATION FOR UL 914

NOTE

ALL DIODES FD300

ALL TRANSISTORS SI7396

CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

RESISTANCE VALUES ARE IN OHMS
K=THOUSAND, M=MILLION

ⓐ INDICATES LOWER CASE LETTER ON CONNECTOR PIN J2

Figure 5-47. Schematic Diagram, 1-2-4-8 Format A17 (Option 04)

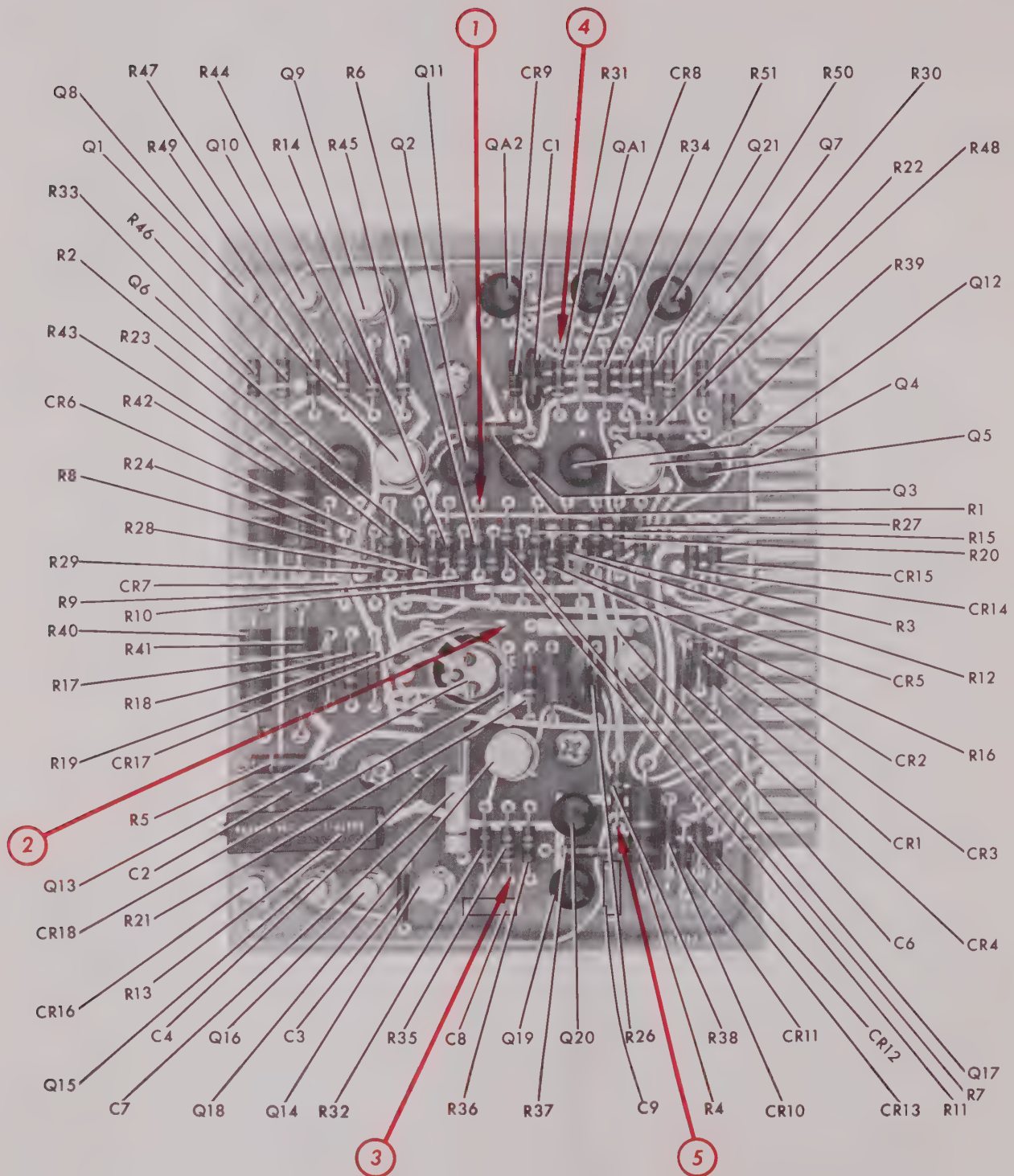


Figure 5-49. Component Location, Power Supply and Logic Assembly A20

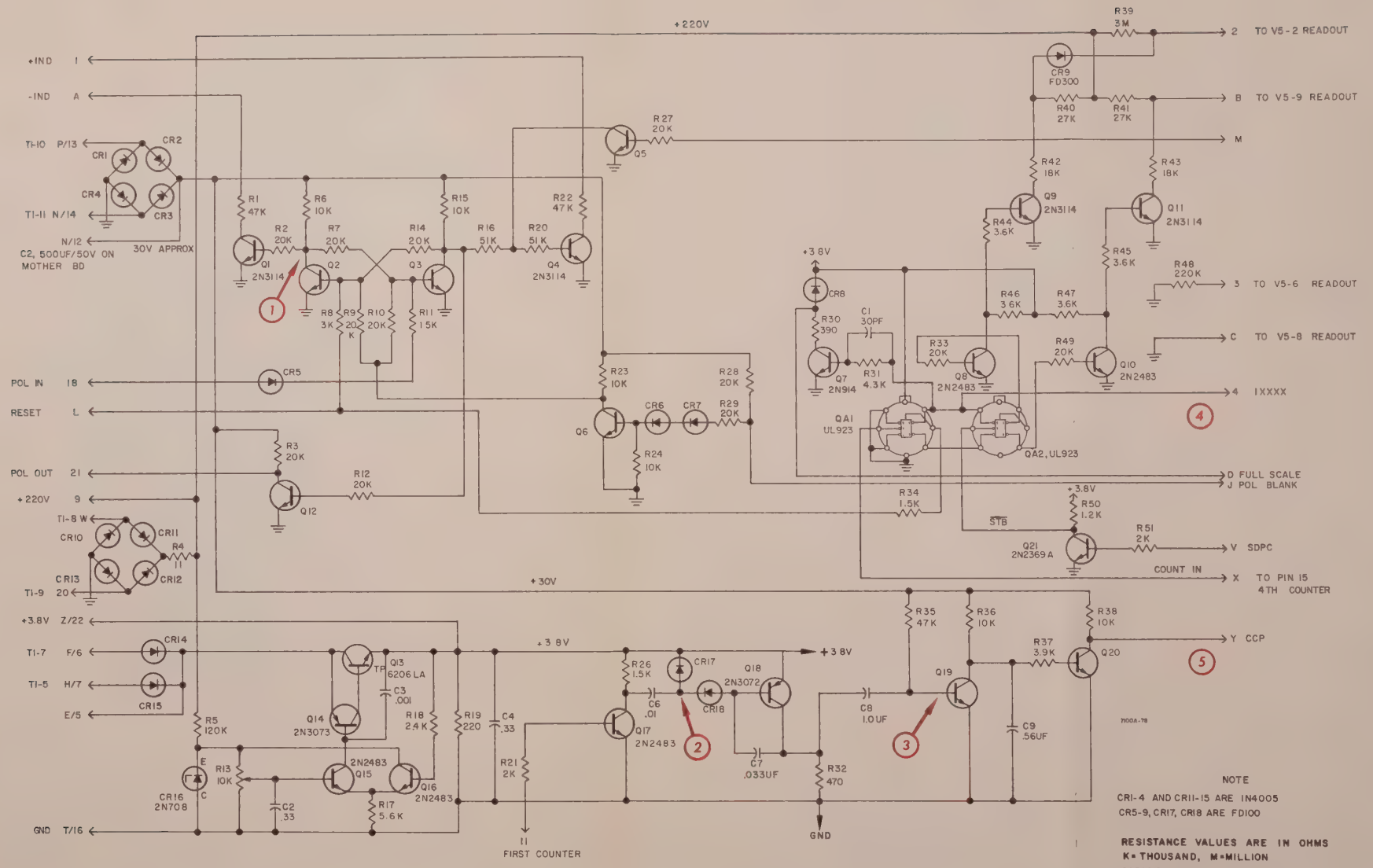


Figure 5-50. Schematic Diagram, Power Supply and Logic A20

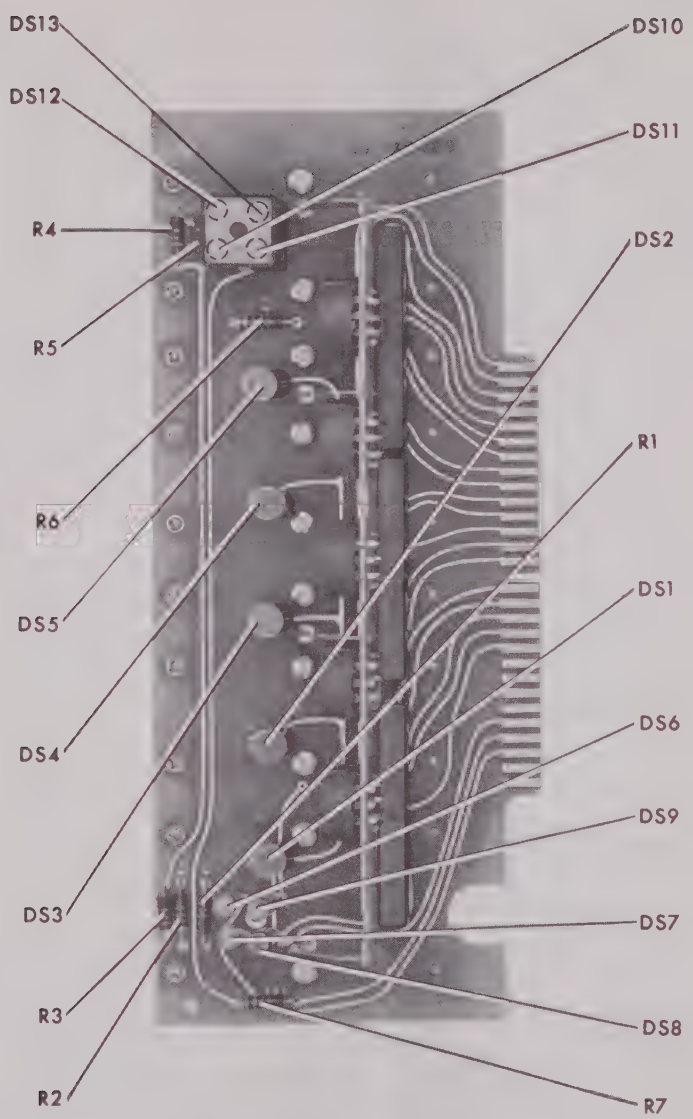


Figure 5-51. Component Location, Display Assembly A21

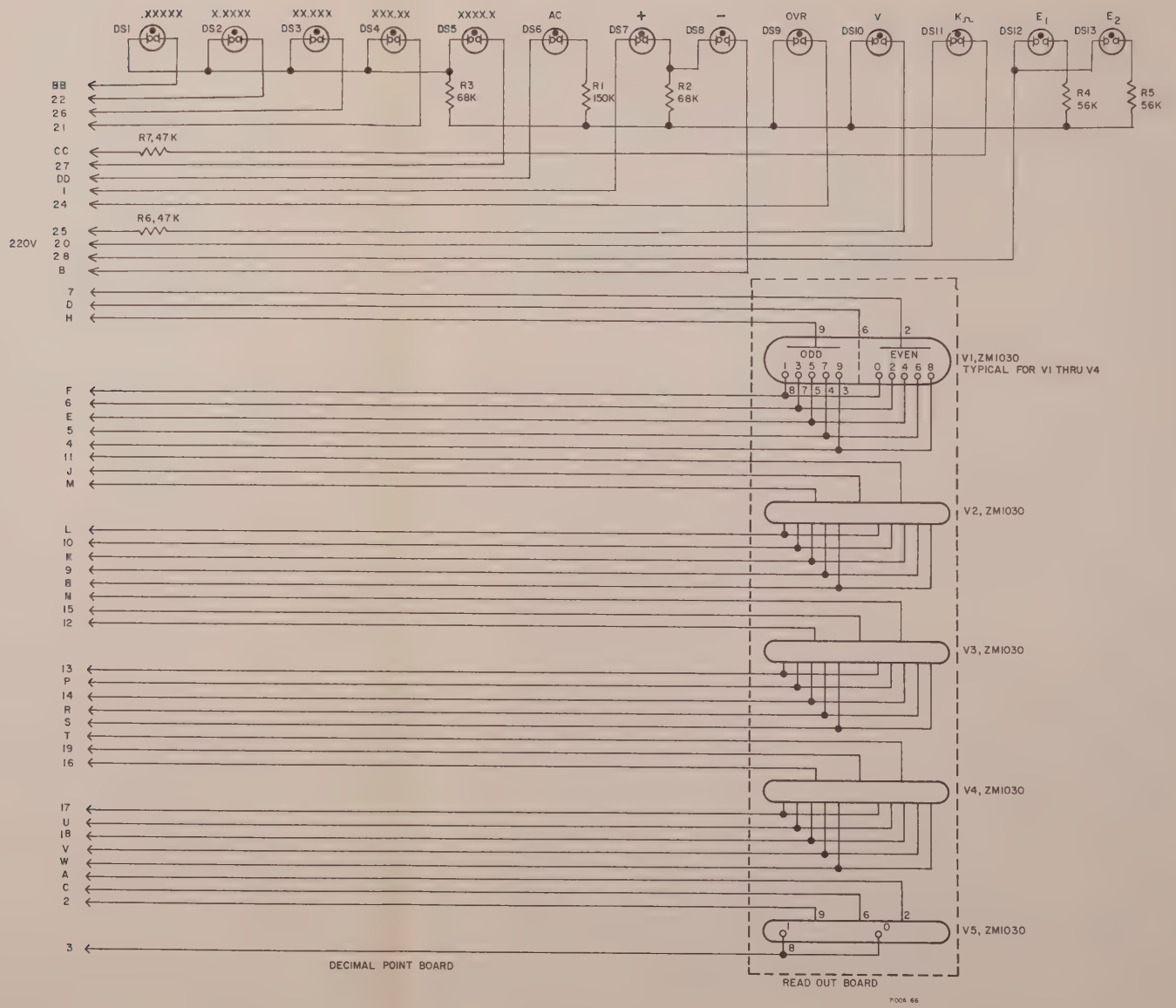


Figure 5-52. Schematic Diagram, Display A21

Section VI
Replacement Parts

6-1. GENERAL

6-2. Tables 6-1 through 6-23 contain information for ordering replacement parts, listing: circuit reference, description, manufacturer, and Fairchild Instrumentation part number.

6-3. ORDERING INFORMATION

6-4. To order a replacement part, address order to an authorized Fairchild Instrumentation sales representative or to: 974 East Arques Avenue, Sunnyvale, California 94086.

6.5 Specify the following for each part:

a. Model and serial number of instrument.

b. Fairchild Instrumentation part number.

c. Circuit reference designation, assembly number, or complete description.

6-6. To order a part not listed in tables 6-1 through 6-23, provide a complete description of the part, including function and location.

ABBREVIATIONS

AB	Allen-Bradley Company
Aerovox	Aerovox Corporation, Hi-Q Div.
Amperex	Amperex Electronics, Inc.
Amphenol	Amphenol-Borg Electronics
Arco	Arco Electronics, Inc.
Belden	Belden Manufacturing Co.
Bourns	Bourns, Inc., Trimpot Division
CD	Cornell-Dubilier Electronics,Inc.
CEC	Consolidated Electrodynamics Corporation
Continental	Continental Device Corporation
CRL	Centralab Div., Globe Union,Inc.
Dale	Dale Electronics, Inc.
Dialco	Dialight Corporation
Electron	Electron Products, Inc.
Elmenco	The Electric Motive Mfg. Co.
FI	Fairchild Instrumentation
FS	Fairchild Semiconductor
Fansteel	Fansteel Metallurgical Corp.
Filtaire	Filtaire, Inc.
GE	General Electric Company
Goodall	Good All Manufacturing Co.
Hamlin	Hamlin, Inc.
Helipot	Helipot Div. of Beckman Inst.
Hopkins	Hopkins Engineering Company
IRC	International Resistance Co.
Johnson	E. F. Johnson Company
Kelvin	Kelvin
Kemet	Kemet Div., Union Carbide, Inc.
Littelfuse	Littelfuse, Inc.
Mallory	Mallory Capacitor Company
Marco	Marco-Oaks Industries
Motorola	Motorola Semiconductor Products
RBM	RBM Controls
RN	Robinson-Nugent, Inc.
Rotron	Rotron Manufacturing Co.
Sprague	Sprague Electric Company
TEC	Transistor Electronics Corp.
TRW	TRW Capacitor Division
Tower	Tower Manufacturing Corp.
Viking	Viking Industries, Inc.
Vishay	Vishay Instrument, Inc.
Welwyn	Welwyn International
Winchester	Winchester Electronics, Div., Retton Industries

Table 6-1. Model 7100A Parts List

Circuit Ref.	Description	Manufacturer	Number
A1	Assembly, Input Switch	FI	93000501
A2	Assembly, Dual Amplifier	FI	93000502
A3	Assembly, Integrator Switch	FI	93000503
A4	Assembly, Clock	FI	93000504
A4	Assembly, Clock, (Option 02 Only)	FI	93000580
A5	Assembly, Dual Power Supply	FI	93000505
A6	Same as A5		
A7	Assembly, Clamp	FI	93000507
A8	Assembly, Amplifier	FI	93000508
A9	Assembly, Range	FI	93000529
A10	Not Assigned		
A11	Assembly, Auto-Range	FI	93000511
A12	Assembly, Mode Matrix	FI	93000512
A13	Assembly, Control Logic	FI	93000513
A14	Assembly, 122*4 Format, (Option 03 Only)	FI	93000584
A14	Assembly, 1248 Format, (Option 04 Only)	FI	93000589
A15	Assembly, Decimal Counter	FI	93000515
A16	Same as A15		
A17	Assembly, 122*4 Format, (Option 03 Only)	FI	93000585
A17	Assembly, 1248 Format, (Option 04 Only)	FI	93000590
A18	Same as A15		
A19	Same as A15		
A20	Assembly, Power Supply and Logic	FI	93000520
A21	Assembly, Display	FI	93000521
A22	Assembly, Parent Board	FI	93000522
A23	Assembly, Parent Board	FI	93000523
B1	Fan	Rotron	81005651
DS14	Lamp, 28 V	Dialco	12013050
E1	Jack, banana, black	Johnson	09056700
F1	Fuse, 1 A	Littelfuse	11009280
J1	Not assigned		
J2	Connector, 50 pin (Options 03 and 04 Only)	Winchester	93000596
J3	Connector, power	Tower	09061480
J4	Connector, input	Amphenol	35087141
J5	Same as J4		
J6	Same as J4		
R1	Resistor, variable, 2.5 MΩ	FI	01094600

Table 6-1. Model 7100A Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
S1	Switch, power, with indicator	Marco	05036160
S2	Switch, slide, DPDT, 115/230 V	Continental	05034320
S3	Same as S2		
T1	Transformer, power		93000534
TB1	Diode, Range	FI	93000532
A25	Extender card	FI	93000525
	MISCELLANEOUS		
	Bail, tilt	FI	35073431
	Cable, input	FI	50303310
	Cable, power	Belden	50303270
	Cover, A-D Converter		33057231
	Cover, A11-A21		33057251
	Cover, top	FI	33057221
	Cover, bottom	FI	33057211
	Filter, light	FI	48006611
	Foot	FI	38020031
	Foot, insert	FI	38023710
	Knob, sample rate	FI	45011250
	Lamp, 28 V (in power switch)	GE	12010950
	Latch, front panel DM-01B	FI	64018440
	Rack Mount Conversion Kit (without slides)	FI	
	Rack Mount Conversion Kit (with slides)	FI	

Table 6-2. Input Switch A1 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 30 pF ±5%, 500 V	Elmenco	03175140
C2	Same as C1		
C3	Capacitor, fixed, 50 pF ±5%, 300 V	Elmenco	03289020
C4	Same as C3		
C5	Capacitor, fixed, .001 μF ±10%, 1000 V	CRL	03270180
CR1	Diode, FD100	FS	26006930
Q1	Transistor, 2N3073	FS	26011430
Q2	Same as Q1		
Q3	Same as Q1		
Q4	Transistor, SP10549	FS	26003861
Q5	Same as Q4		
Q6	Same as Q4		
Q7	Transistor, 2N915	FS	26007050
Q8	Same as Q7		
Q9	Same as Q7		
Q10	Transistor, 2N2484	FS	26010670
Q11	Transistor, 2N2483	FS	26010780
Q12	Same as Q11		
Q13	Same as Q11		
Q14	Same as Q11		
Q15	Same as Q11		
Q16	Same as Q11		
R1	Resistor, variable, 1 kΩ	Helipot	01110260
R2	Resistor, fixed, 4.75 kΩ ±1%, ½ W	CEC	02379080
R3	Resistor, fixed, 470 Ω ±5%, ½ W	AB	02030400
R4	Resistor, fixed, 4.99 kΩ ±1%, ½ W	AB	02379100
R5	Same as R3		
R6	Same as R4		
R7	Resistor, fixed, 1 kΩ ±1%, ½ W	CEC	02378430
R8	Resistor, fixed, 3.9 kΩ ±5%, ½ W	AB	02030620
R9	Resistor, fixed, 33 kΩ ±5%, ½ W	AB	02030840
R10	Resistor, fixed, 6.8 kΩ ±5%, ½ W	AB	02030680
R11	Resistor, fixed, 5.1 kΩ ±5%, ½ W	AB	02030650
R12	Resistor, fixed, 68 kΩ ±5%, ½ W	AB	02030920
R13	Same as R9		
R14	Same as R12		
R15	Same as R11		
R16	Same as R10		
R17	Same as R12		
R18	Same as R11		
R19	Same as R10		

Table 6-2. Input Switch A1 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R20	Resistor, fixed, 10 kΩ ±1%, ½ W	CEC	02379390
R21	Resistor, fixed, 1 kΩ ±5%, ½ W	AB	02030480
R22	Same as R7		
R23	Same as R10		
R24	Same as R9		
R25	Same as R10		
R26	Same as R12		
R27	Same as R12		
R28	Same as R10		
R29	Same as R12		
R30	Same as R10		
R31	Same as R10		
R32	Same as R12		
R33	Same as R10		
R34	Same as R12		
R35	Same as R10		
R36	Resistor, fixed, 10 kΩ ±5%, ½ W	AB	02030720
R37	Same as R10		
R38	Same as R36		
R39	Same as R12		
R40	Same as R12		
R41	Same as R12		
R42	Same as R12		
R43	Same as R12		
R44	Same as R12		

Table 6-3. Dual Amplifier A2 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, .033 μF ±10%, 200 V	TRW	03278940
C2	Same as C1		
C3	Capacitor, fixed, 50 pF ±5%, 300 V	Arco	03175200
C4	Same as C3		
C5	Capacitor, fixed, 1 μF ±20%, 100 V	Hopkins	03279360
C6	Capacitor, fixed, 30 pF ±5%, 500 V	Elmenco	03175140
C7	Same as C6		
CR1	Diode, FD100	FS	26006930
CR2	Same as CR1		
Q1	Transistor, 2N2920	FS	26011350
Q2	Same as Q1		
Q3	Same as Q1		
Q4	Same as Q1		
Q5	Transistor, 2N2484	FS	26010670
Q6	Same as Q5		
Q7	Transistor, 2N3073	FS	26011430
Q8	Transistor, 2N722	FS	26011100
Q9	Transistor, 2N720A	FS	26010850
Q10	Same as Q8		
Q11	Transistor, 2N1132	FS	26007150
Q12	Transistor, 0019HA	FS	26012100
Q13	Same as Q1		
R1	Resistor, fixed, 1.2 MΩ ±5%, ½ W	AB	02031220
R2	Resistor, variable, 2 kΩ	Helipot	01095350
R3	Resistor, fixed, 160 kΩ ±5%, ½ W	AB	02031010
R4	Resistor, fixed, 4.7 MΩ ±5%, ½ W	AB	02031360
R5	Resistor, fixed, 36.5 kΩ ±1%, ½ W	RN	02392150
R6	Resistor, fixed, 240 Ω ±5%, ½ W	AB	02030330
R7	Resistor, fixed, 47 kΩ ±5%, ½ W	AB	02030880
R8	Resistor, fixed, 22.1 kΩ ±1%, ½ W	IRC	02401370
R9	Same as R4		
R10	Resistor, fixed, 3 kΩ ±5%, ½ W	AB	02030590
R11	Resistor, variable, 1 kΩ	Helipot	01094910
R12	Resistor, fixed, 220 Ω ±5%, ½ W	AB	02030320
R13	Resistor, fixed, 10 kΩ ±5%, ½ W	AB	02030720
R14	Same as R7		
R15	Resistor, fixed, 100 Ω ±5%, ½ W	AB	02030240
R16	Same as R15		
R17	Resistor, fixed, 300 kΩ ±5%, ½ W	AB	02031070
R18	Resistor, fixed, 15 kΩ ±1%, ½ W	IRC	02379560
R19	Resistor, fixed, 3 kΩ ±.01%, .3 W	Vishay	02402180

Table 6-3. Dual Amplifier A2 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R20	Same as R4		
R21	Resistor, fixed, 36 kΩ ±5%, ½ W	AB	02030850
R22	Same as R6		
R23	Resistor, fixed, 22 kΩ ±5%, ½ W	AB	02030800
R24	Same as R4		
R25	Same as R10		
R26	Resistor, fixed, 1.5 kΩ ±5%, ½ W	AB	02030520
R27	Same as R19		
R28	Resistor, fixed, 30 kΩ ±5%, ½ W	AB	02030830
R29	Same as R11		
R30	Same as R12		
R31	Same as R7		
R32	Same as R23		
R33	Same as R15		
R34	Same as R17		

Table 6-4. Integrator Switch A3 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 0.22 μF ±5%, 100 V	Goodall	03279500
C2	Same as C1		
C3	Capacitor, fixed, 0.1 μF ±5%, 100 V	Goodall	03279490
C4	Capacitor, fixed, 0.0022 μF ±10%, 200 V	TRW	03278860
C5	Capacitor, fixed, 50 pF ±5%, 300 V	Elmenco	03289020
C6	Same as C5		
C7	Capacitor, fixed, 560 pF ±5%, 300 V	Elmenco	03281520
CR1	Diode, FD100	FS	26006930
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
Q1	Transistor, 2N2297	FS	26010440
Q2	Same as Q1		
Q3	Transistor, 2N2483	FS	26010780
Q4	Same as Q3		
Q5	Same as Q3		
Q6	Transistor, 2N834	FS	26011580
Q7	Same as Q3		
Q8	Same as Q3		
R1	Resistor, factory selected value		
R2	Resistor, variable, 100 Ω	Helipot	01110230
R3	Resistor, fixed, 249 Ω ±1%, ½ W	CEC	02377850
R4	Resistor, fixed, 4.7 MΩ ±5%, ½ W	AB	02031360
R5	Resistor, fixed, 10 Ω ±5%, ½ W	AB	02030000
R6	Resistor, fixed, 40.2 kΩ ±1%, ½ W	CEC	02379970
R7	Resistor, variable, 50 kΩ	Helipot	01095360
R8	Resistor, fixed, 43 kΩ ±5%, ½ W	AB	02030870
R9	Resistor, fixed, 91 kΩ ±5%, ½ W	AB	02030950
R10	Resistor, fixed, 10 kΩ ±5%, ½ W	AB	02030720
R11	Same as R10		
R12	Resistor, fixed, 2 kΩ ±5%, ½ W	AB	02030550
R13	Same as R10		
R14	Resistor, fixed, 47 kΩ ±5%, ½ W	AB	02030880
R15	Resistor, fixed, 68 kΩ ±5%, ½ W	AB	02030920
R16	Same as R15		
R17	Resistor, fixed, 33 kΩ ±5%, ½ W	AB	02030840
R18	Same as R15		
R19	Resistor, fixed, 7.5 kΩ ±5%, ½ W	AB	02030690

Table 6-4. Integrator Switch A3 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R20	Same as R15		
R21	Same as R14		
R22	Resistor, fixed, 82 kΩ ±5%, ½ W	AB	02030940
R23	Resistor, fixed, 6.8 kΩ ±5%, ½ W	AB	02030680
R24	Same as R15		
R25	Resistor, fixed, 12 kΩ ±5%, ½ W	AB	02030740
R26	Same as R22		
R27	Same as R23		
R28	Resistor, fixed, 1 kΩ ±5%, ½ W	AB	02030480
R29	Same as R22		
R30	Same as R23		
R31	Resistor, fixed, 6.2 kΩ ±5%, ½ W	AB	02030670
A1	Voltage reference RVL-1	FI	91004100

Table 6-5. Clock A4 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 33 pF ±5%, 500 V	Elmenco	03175150
C2	Same as C1		
C3	Same as C1		
C4	Same as C1		
C5	Same as C1		
C6	Capacitor, fixed, .001 μF, 1000 V	CRL	03270180
C7	Capacitor, fixed, 100 pF ±5%, 500 V	Elmenco	03281320
C8	Capacitor, fixed, .001 μF ±10%, 100 V	TRW	03278790
C9	Same as C6		
C10	Capacitor, fixed, .01 μF, 50 V	CRL	03279910
C11	Same as C10		
C12	Same as C10		
CR1	Diode, FD100	FS	26006930
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR1		
CR9	Same as CR1		
Q1	Transistor, S19815	FS	26003921
Q2	Same as Q1		
Q3	Same as Q1		
Q4	Same as Q1		
Q5	Same as Q1		
Q6	Same as Q1		
Q7	Same as Q1		
Q8	Transistor, S18174	FS	26003911
Q9	Same as Q1		
Q10	Same as Q1		
Q11	Same as Q1		
Q12	Same as Q1		
Q13	Same as Q1		
Q14	Same as Q1		
Q15	Same as Q1		
Q16	Same as Q1		
Q17	Same as Q1		
Q18	Same as Q1		
Q19	Same as Q1		
Q20	Transistor, S17396	FS	26003851

Table 6-5. Clock A4 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R1	Resistor, fixed, 3.6 kΩ ±5%, ¼ W	AB	02354740
R2	Same as R1		
R3	Same as R1		
R4	Same as R1		
R5	Same as R1		
R6	Resistor, fixed, 13 kΩ ±5%, ¼ W	AB	02354880
R7 through R25	Same as R6		
R26	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R27	Same as R26		
R28	Same as R26		
R29	Same as R26		
R30	Same as R26		
R31	Same as R1		
R32	Resistor, fixed, 22 kΩ ±5%, ¼ W	AB	02354930
R33	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R34	Same as R33		
R35	Resistor, fixed, 1.5 kΩ ±5%, ¼ W	AB	02354650
R36	Resistor, fixed, 1.6 kΩ ±5%, ½ W	AB	02030530
R37	Same as R36		
R38	Resistor, fixed, 20 kΩ ±5%, ¼ W	AB	02354920
R39	Same as R38		
R40	Same as R38		
R41	Same as R38		
R42	Same as R38		
R43	Same as R38		
R44	Resistor, fixed, 15 kΩ ±5%, ¼ W	AB	02354890
R45	Same as R26		
R46	Same as R32		
R47	Same as R33		
R48	Same as R32		
R49	Resistor, fixed, 390 kΩ ±5%, ¼ W	AB	02355230
R50	Resistor, fixed, 33 kΩ ±5%, ¼ W	AB	02354970
R51	Resistor, variable, 50 kΩ	Bourns	01111140
R52	Resistor, fixed, 62 kΩ ±5%, ¼ W	AB	02355040
R53	Same as R26		
R54	Resistor, variable, 20 kΩ	Bourns	01094820
R55	Resistor, fixed, 100 kΩ ±5%, ¼ W	AB	02355090
R56	Resistor, fixed, 6.8 kΩ ±5%, ¼ W	AB	02354810
R57	Same as R32		
R58	Same as R38		
R59	Same as R38		

Table 6-5. Clock A4 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R60	Same as R38		
R61	Same as R55		
R62	Same as R38		
R63	Same as R38		
R64	Same as R38		
R65	Same as R26		
R66	Same as R38		
R67	Resistor, fixed, 10 kΩ ±5%, ½ W	AB	02030720
R68	Resistor, fixed, 3 kΩ ±5%, ½ W	AB	02030590
R69	Same as R50		
R70	Same as R50		
R71	Resistor, variable, 50 kΩ	Helipot	01110320
R72	Same as R50		
Y1	Crystal, 600 kHz	Filtaire	27004791

Table 6-6. Dual Power Supply A5 and A6 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 70 μ, 60 V	Mallory	03279580
C2	Capacitor, fixed, 140 μF, 60 V	Sprague	03287660
C3	Capacitor, fixed, 2000 pF, 1000 V	CD	03281710
C4	Same as C3		
C5	Capacitor, fixed, 1 μF ±20%, 100 V	Hopkins	03279360
C6	Capacitor, fixed, 5 μF, 50 V	CD	03267620
C7	Same as C6		
CR1	Diode, 1N4003	Motorola	26011080
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Diode, FD100	FS	26006930
CR7	Same as CR6		
CR8	Same as CR6		
CR9	Same as CR1		
Q1	Transistor, 2N3563	FS	26012050
Q2	Transistor, 2N3638	FS	26011930
Q3	Transistor, S17396	FS	26003851
Q4	Transistor, 2N3073	FS	26011430
Q5	Same as Q4		
Q6	Same as Q1		
Q7	Transistor, 2N3108	FS	26012040
Q8	Transistor, S19428	FS	26003901
Q9	Same as Q8		
Q10	Same as Q1		
Q11	Transistor, 2N2483	FS	26010780
Q12	Same as Q11		
Q13	Same as Q7		
Q14	Same as Q4		
Q15	Same as Q4		
Q16	Same as Q4		
Q17	Transistor, S17334	FS	26003391
R1	Not assigned		
R2	Resistor, fixed, 3.9 Ω ±5%, ½ W	AB	02401590
R3	Resistor, fixed, 3.3 kΩ ±5%, ½ W	AB	02030600
R4	Resistor, fixed, 39 kΩ ±5%, ½ W	AB	02030860
R5	Resistor, fixed, 62 kΩ ±5%, ½ W	AB	02030910
R6	Same as R2		
R7	Resistor, fixed, 300 kΩ ±5%, ½ W	AB	02031070
R8	Resistor, fixed, 150 kΩ ±5%, ½ W	AB	02031000

Table 6-6. Dual Power Supply A5 and A6 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R9	Resistor, fixed, 6.2 kΩ ±5%, ½ W	AB	02030670
R10	Same as R8		
R11	Resistor, fixed, 30 kΩ ±5%, ½ W	AB	02030830
R12	Resistor, fixed, 15 kΩ ±5%, ½ W	AB	02030760
R13	Resistor, fixed, 33 kΩ ±5%, ½ W	AB	02030840
R14	Same as R8		
R15	Resistor, fixed, 15 Ω ±5%, ½ W	AB	02030040
R16	Resistor, fixed, 21.5 kΩ ±1%, .5 W	IRC	02379710
R17	Resistor, variable, 1 kΩ	Bourns	01094780
R18	Resistor, fixed, 5.62 kΩ ±1%, 1/8 W	IRC	02379150
R19	Resistor, fixed, 46.4 kΩ ±1%, .5 W	IRC	02380030
R20	Same as R19		
R21	Same as R15		

Table 6-7. Clamp A7 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, .05 μF ±20%, 50 V	Sprague	03281790
CR1	Diode, FD300	FS	26012320
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
Q1	Transistor, 2N2484	FS	26010670
Q2	Transistor, 2N3965	FS	26012100
Q3	Transistor, 2N722	FS	26011100
Q4	Transistor, S17396	FS	26003851
Q5	Same as Q4		
R1	Resistor, fixed, 220 Ω ±5%, ½ W	AB	02030320
R2	Resistor, fixed, 470 Ω ±5%, ½ W	AB	02030400
R3	Same as R2		
R4	Resistor, fixed, 1 kΩ ±5%, ½ W	AB	02030480
R5	Same as R4		
R6	Resistor, fixed, 47 kΩ ±5%, ½ W	AB	02030880
R7	Resistor, fixed, 15 kΩ ±1%, ½ W	Welwyn	02379560
R8	Resistor, fixed, 200 Ω ±5%, ½ W	AB	02030310
R9	Same as R8		
R10	Same as R7		
R11	Same as R6		
R12	Resistor, fixed, 100 kΩ ±5%, ½ W	AB	02030960
R13	Resistor, fixed, 7.5 kΩ ±1%, ½ W	AB	02379270
R14	Same as R13		
R15	Resistor, fixed, 22 kΩ ±5%, ½ W	AB	02030800
R16	Resistor, fixed, 620 Ω ±5%, 1 W	AB	02402670

Table 6-8. Amplifier A8 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 300 pF ±5%, 500 V	Elmenco	03281440
C2	Capacitor, fixed, 22 μF ±20%, 35 V	Fansteel	03282740
C3	Capacitor, fixed, .01 μF ±10%, 200 V	Goodall	03278910
C4	Capacitor, fixed, 10 μF ±10%, 20 V	Fansteel	03280110
C5	Capacitor, fixed, .47 μF ±20%, 100 V	Electron	03279430
C6	Capacitor, fixed, .1 μF ±10%, 100 V	TRW	03281810
C7	Capacitor, fixed, .047 μF ±10%, 100 V	TRW	03278810
C8	Same as C3		
C9	Same as C5		
C10	Same as C6		
C11	Capacitor, fixed, .022 μF ±10%, 200 V	Goodall	03278930
C12	Same as C2		
C13	Same as C2		
C14	Capacitor, fixed, 100 μF ±10%, 15 V	Fansteel	03282600
C15	Capacitor, fixed, .22 μF ±10%, 100 V	Goodall	03278830
C16	Same as C3		
C17	Capacitor, fixed, 75 pF ±5%, 500 V	Elmenco	03175250
C18	Capacitor, fixed, 360 pF ±5%, 500 V	Elmenco	03281460
C19	Same as C3		
C20	Capacitor, fixed, 200 pF ±5%, 300 V	Elmenco	03281390
CR1	Transistor, S17685	FS	26003681
CR2	Same as CR1		
CR3	Diode, FD200	FS	26011850
CR4	Same as CR3		
CR5	Same as CR3		
CR6	Same as CR3		
CR7	Same as CR1		
CR8	Transistor, 2N706	FS	26010790
CR9	Same as CR3		
CR10	Same as CR3		
CR11	Transistor, S17391	FS	26003841
DS1	Lamp, neon NE2U	GE	12013110
DS2	Same as DS1		
Q1	Transistor, S17395	FS	26003741
Q2	Transistor, 2N956	FS	26010820
Q3	Transistor, 2N7180	FS	26011150
Q4	Same as Q3		
Q5	Transistor, 2N718	FS	26010840
Q6	Same as Q1		
Q7	Same as Q1		
Q8	Same as Q1		

Table 6-8. Amplifier A8 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
Q9	Transistor, 2N3073	FS	26011430
Q10	Transistor, 2N720A	FS	26010850
Q11	Transistor, 2N699	FS	26010490
Q12	Transistor, 2N1132	FS	26007150
Q13	Same as Q5		
Q14	Same as Q5		
Q15	Same as Q1		
Q16	Same as Q1		
R1	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R2	Resistor, fixed, 6.2 kΩ ±5%, ¼ W	AB	02354800
R3	Resistor, fixed, 300 kΩ ±5%, ¼ W	AB	02355200
R4	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R5	Photoconductor type 3H5	FS	26015110
R6	Same as R5		
R7	Resistor, fixed, 22 kΩ ±5%, ¼ W	AB	02354930
R8	Resistor, fixed, 1.1 MΩ ±5%, ¼ W	AB	02355340
R9	Resistor, fixed, 200 kΩ ±5%, ¼ W	AB	02355160
R10	Same as R9		
R11	Resistor, fixed, 4.7 MΩ ±5%, ¼ W	AB	02355490
R12	Same as R11		
R13	Same as R7		
R14	Resistor, fixed, 470 kΩ ±5%, ¼ W	AB	02355250
R15	Resistor, fixed, 2.7 Ω ±5%, ¼ W	AB	02354000
R16	Same as R4		
R17	Resistor, fixed, 56 kΩ ±5%, ¼ W	AB	02355030
R18	Resistor, fixed, 330 kΩ ±5%, ¼ W	AB	02355210
R19	Same as R2		
R20	Same as R7		
R21	Same as R7		
R22	Resistor, fixed, 68 kΩ ±5%, ¼ W	AB	02355050
R23	Same as R7		
R24	Resistor, fixed, 1 kΩ ±5%, ¼ W	AB	02354620
R25	Resistor, fixed, 150 kΩ ±5%, ¼ W	AB	02355130
R26	Resistor, fixed, 560 kΩ ±5%, ¼ W	AB	02355270
R27	Resistor, fixed, 100 Ω ±5%, ¼ W	AB	02354380
R28	Same as R27		
R29	Same as R26		
R30	Not assigned		
R31	Same as R11		
R32	Resistor, fixed, 47 Ω ±5%, ¼ W	AB	02354300
R33	Same as R15		
R34	Resistor, fixed, 360 kΩ ±5%, ¼ W	AB	02355220

Table 6-8. Amplifier A8 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R35	Resistor, fixed, 680 kΩ ±5%, ¼ W	AB	02355290
R36	Same as R15		
R37	Same as R11		
R38	Same as R2		
R39	Resistor, fixed, 820 Ω ±5%, ¼ W	AB	02354600
R40	Same as R1		
R41	Resistor, fixed, 510 Ω ±5%, ¼ W	AB	02354550
R42	Resistor, fixed, 91 kΩ ±5%, ¼ W	AB	02355080
R43	Same as R7		
R44	Resistor, fixed, 3.3 kΩ ±5%, ¼ W	AB	02354730
R45	Resistor, fixed, 15 kΩ ±5%, ¼ W	AB	02354890
R46	Same as R32		
R47	Resistor, fixed, 220 Ω ±5%, ¼ W	AB	02354460
R48	Same as R47		
R49	Same as R32		
R50	Resistor, fixed, 18 kΩ ±5%, ¼ W	AB	02354910
R51	Resistor, fixed, 10 Ω ±5%, ¼ W	AB	02354140
R52	Resistor, fixed, 5.1 MΩ ±5%, ¼ W	AB	02355500

Table 6-9. Range A9 Parts List

Circuit Ref.	Description	Manufacturer	Number
K1	Relay, reed	Hamlin	05033810
K2	Same as K1		
K3	Relay, reed		
K4	Same as K1		
K5	Not assigned		
K6	Same as K1		
K7	Same as K1		
K8	Not assigned		
K9	Same as K1		
K10	Same as K1		
K11	Same as K1		
K12	Same as K1		
K13	Same as K1		
K14	Same as K1		
K15	Same as K1		
K16	Same as K1		
K17	Same as K1		
K18	Not assigned		
K19	Same as K1		
K20	Same as K1		
K21	Same as K1		
R1	Resistor, variable, 1 kΩ	Helipot	01110260
R2*	Resistor, fixed, 179.50 kΩ, ¼ W	Kelvin	
R3	Resistor, variable, 100 Ω	Helipot	01110230
R4*	Resistor, fixed, 17.950 kΩ, ½ W	Kelvin	
R5*	Resistor, fixed, 2 kΩ, 1.5 W	Kelvin	
R6	Resistor, fixed, 10 kΩ ±5%, 1 W	AB	02033720
R7	Resistor, fixed, 50 kΩ ±1%, 10 W	Dale	02402760
R8	Same as R7		
R9**	Resistor, fixed, 8.94 MΩ, 1/5 W	Kelvin	
R10	Resistor, variable, 20 kΩ	Helipot	01110300
R11	Resistor, variable, 10 kΩ	Helipot	01110290
R12**	Resistor, fixed, 899 kΩ, ½ W	Kelvin	
R13	Same as R1		
R14**	Resistor, fixed, 89.9 kΩ, ¼ W	Kelvin	
R15	Same as R3		
R16**	Resistor, fixed, 9.99 kΩ, ½ W	Kelvin	
	* Matched set: Stock number 02392331		
	** Matched set: Stock number 02392321		

Table 6-10. Auto Range A11 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1 through C8	Capacitor, fixed, .022 μF ±10%, 200 V	TRW	03278930
CR1 through CR8	Diode, FD100	FS	26006930
CR9 through CR17	Diode, FD300	FS	26012320
Q1 through Q14	Transistor, S17396	FS	26003851
R1	Resistor, fixed, 39 kΩ ±5%, ½ W	AB	02030860
R2	Same as R1		
R3	Same as R1		
R4	Same as R1		
R5	Resistor, fixed, 8.2 kΩ ±5%, ½ W	AB	02030700
R6	Same as R5		
R7	Same as R5		
R8	Same as R5		
R9	Same as R5		
R10	Same as R1		
R11 through R33	Same as R1		
R34 through R43	Resistor, fixed, 5.1 kΩ ±5%, ½ W	AB	02030650

Table 6-11. Mode Matrix A12 Parts List

1

Circuit Ref.	Description	Manufacturer	Number
CR1 through CR9	Not assigned		
CR10	Diode, FD100	FS	26006930
CR11	Same as CR10		
CR12	Same as CR10		
CR13	Same as CR10		
CR14	Diode, 1N4005	FS	26012270
CR15	Same as CR14		
CR16 through CR64	Same as CR10		
CR65 through CR69	Diode, FD300	FS	26012320
CR70 through CR74	Same as CR10		
CR75	Not assigned		
CR76	Same as CR10		
CR77	Same as CR10		
CR78	Not assigned		
CR79	Same as CR10		
CR80	Same as CR65		
CR81	Same as CR65		
CR82 through CR86	Same as CR10		
Q1 through Q8	Transistor, 2N3114	FS	26008620
Q9 through Q22	Transistor, S17396	FS	26003851
R1 through R14	Resistor, fixed, 150 kΩ ±5%, ½ W	AB	02031000
R15	Not assigned		
R16	Resistor, fixed, 10 kΩ ±5%, ½ W	AB	02030720
R17 through R24	Not assigned		
R25	Resistor, fixed, 5.1 MΩ ±5%, ½ W	AB	02031370

Table 6-11. Mode Matrix A12 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R26	Same as R25		
R27	Not assigned		
R28	Same as R1		
R29	Resistor, fixed, 51 kΩ ±5%, ½ W	AB	02030890
R30	Same as R1		

Table 6-12. Control Logic A13 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 1 μF, 50 V	Sprague	03267660
C2	Capacitor, fixed, 6.8 μF ±20%, 35 V	Fansteel	03282710
C3	Capacitor, fixed, .01 μF ±10%, 200 V	Goodall	03278910
C4	Capacitor, fixed, 1 μF ±20%, 100 V	Goodall	03279360
C5	Capacitor, fixed, 510 pF ±5%, 500 V	Elmenco	03281510
C6	Same as C3		
CR1	Diode, FD100	FS	26006930
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
Q1 through Q8	Transistor, S17396	FS	26003851
Q9	Transistor, 2N3114	FS	26008620
Q10 through Q18	Same as Q1		
QA1	Micrologic element, μL911	FS	26011920
QA2	Micrologic element, μL910	FS	26011160
QA3	Same as QA2		
QA4	Same as QA1		
QA5	Same as QA2		
QA6	Same as QA2		
QA7	Same as QA2		
QA8	Same as QA1		
QA9	Same as QA1		
QA10	Same as QA2		
R1	Resistor, fixed, 20 kΩ ±5%, ¼ W	AB	02354920
R2	Same as R1		
R3	Resistor, fixed, 1.5 kΩ ±5%, ¼ W	AB	02354650
R4	Same as R1		
R5	Resistor, fixed, 3.6 kΩ ±5%, ¼ W	AB	02354740
R6	Same as R1		
R7	Same as R1		
R8	Same as R3		
R9	Same as R1		
R10	Same as R5		
R11	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R12	Same as R1		
R13	Same as R1		
R14	Resistor, fixed, 2 kΩ ±5%, ¼ W	AB	02354680
R15	Same as R1		

Table 6-12. Control Logic A13 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R16	Same as R11		
R17	Resistor, fixed, 1.5 MΩ ±5%, ¼ W	AB	02355370
R18	Resistor, fixed, 100 kΩ ±5%, ¼ W	AB	02355090
R19	Resistor, fixed, 5.1 MΩ ±5%, ¼ W	AB	02354780
R20	Resistor, fixed, 7.5 kΩ ±5%, ¼ W	AB	02354820
R21	Resistor, fixed, 1 kΩ ±5%, ¼ W	AB	02354620
R22	Same as R1		
R23	Same as R1		
R24	Same as R1		
R25	Same as R1		
R26	Same as R11		
R27	Resistor, fixed, 36 kΩ ±5%, ¼ W	AB	02354980
R28	Same as R11		
R29	Same as R1		
R30	Same as R5		
R31	Same as R1		
R32	Same as R1		
R33	Same as R1		
R34	Same as R1		
R35	Same as R1		
R36	Resistor, fixed, 56 kΩ ±5%, ¼ W	AB	02355030
R37	Same as R5		
R38	Resistor, fixed, 3.9 kΩ ±5%, ¼ W	AB	02354750
R39	Same as R1		
R40	Same as R11		
R41	Same as R11		
R42	Resistor, fixed, 510 Ω ±5%, ¼ W	AB	02354550
R43	Resistor, fixed, 220 Ω ±5%, ¼ W	AB	02354460
R44	Resistor, fixed, 10 Ω ±5%, ¼ W	AB	02354140
R45	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R46	Same as R36		
R47	Same as R1		
R48	Same as R1		
R49	Same as R1		
R50	Same as R1		
R51	Same as R1		
R52	Same as R1		
R53	Same as R1		
R54	Same as R1		
R55	Same as R1		
R56	Same as R11		
R57	Same as R11		

Table 6-12. Control Logic A13 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R58	Same as R11		
R59	Resistor, fixed, 1 MΩ ±5%, ¼ W	AB	02355330
R60	Same as R1		
R61	Same as R1		
R62	Same as R5		

Table 6-13. 1-2-2-4 Format A14 (Option 03 Only) Parts List*

Circuit Ref.	Description	Manufacturer	Number
Q1 through Q9	Transistor, S17396	FS	26003851
R1	Resistor, fixed, 20 kΩ ±5%, ½ W	AB	02030790
R2	Resistor, fixed, 2 kΩ ±5%, ½ W	AB	02030550
R3	Same as R1		
R4	Same as R2		
R5	Same as R1		
R6	Same as R2		
R7	Same as R1		
R8	Same as R2		
R9	Same as R1		
R10	Same as R2		
R11	Same as R1		
R12	Same as R2		
R13	Same as R1		
R14	Same as R2		
R15	Same as R1		
R16	Same as R2		
R17	Resistor, fixed, 3.6 kΩ ±5%, ½ W	AB	02030610
R18	Same as R1		
R19	Resistor, fixed, 3.9 kΩ ±5%, ½ W	AB	02030620
R20	Same as R2		

Table 6-14. 1-2-4-8 Format A14 (Option 04 Only) Parts List

Circuit Ref.	Description	Manufacturer	Number
Q1 through Q9	Transistor, S17396	FS	26003851
QA1	Micrologic element, μL927	FS	26012110
QA2	Same as QA1		
QA3	Micrologic element, μL915	FS	26012070
QA4	Same as QA3		
QA5	Micrologic element, μL914	FS	26010980
QA6	Same as QA1		
QA7	Same as QA1		
QA8	Same as QA3		
QA9	Same as QA3		
QA10	Same as QA5		
R1	Resistor, fixed, 3.6 kΩ ±5%, ¼ W	AB	02354740
R2	Resistor, fixed, 2 kΩ ±5%, ¼ W	AB	02354680
R3	Resistor, fixed, 20 kΩ ±5%, ¼ W	AB	02354920
R4	Same as R2		
R5	Same as R3		
R6	Same as R2		
R7	Same as R3		
R8	Same as R3		
R9	Same as R3		
R10	Same as R3		
R11	Same as R3		
R12	Same as R3		
R13	Resistor, fixed, 3.9 kΩ ±5%, ¼ W	AB	02354750
R14	Same as R2		

Table 6-15. Decimal Counter A15, 16, 18, 19 Parts List

Circuit Ref.	Description	Manufacturer	Number
CR1	Diode, FD300	FS	26012320
Q1 through Q7	Transistor, 2N3114	FS	26008620
Q8	Transistor, 2N2484	FS	26010670
Q9	Same as Q8		
Q10	Transistor, 2N2369A	FS	26011140
QA1	Micrologic element, μL910	FS	26011160
QA2	Same as QA1		
QA3	Same as QA1		
QA4	Micrologic element, μL924	FS	26012480
QA5	Micrologic element, μL923-27	FS	26012150
QA6 through QA11	Same as QA5		
QA12	Micrologic element, μL914	FS	26010980
R1	Resistor, fixed, 27 kΩ ±5%, 1 W	AB	02033820
R2	Resistor, fixed, 18 kΩ ±5%, 1 W	AB	02033780
R3	Resistor, fixed, 3.6 kΩ ±5%, ½ W	AB	02030610
R4	Same as R1		
R5	Resistor, fixed, 3 MΩ ±5%, ½ W	AB	02031310
R6	Same as R2		
R7	Same as R3		
R8	Resistor, fixed, 220 kΩ ±5%, ½ W	AB	02031040
R9	Same as R3		
R10	Same as R3		
R11	Resistor, fixed, 20 kΩ ±5%, ½ W	AB	02030790
R12	Same as R11		
R13	Resistor, fixed, 680 Ω ±5%, ½ W	AB	02030440
R14	Resistor, fixed, 2 kΩ ±5%, ½ W	AB	02030550
R15	Resistor, fixed, 1.5 kΩ ±5%, ½ W	AB	02030520
R16	Same as R15		
R17	Same as R15		
R18	Same as R15		

Table 6-16. 1-2-2-4 Format A17 (Option 03 Only) Parts List*

Circuit Ref.	Description	Manufacturer	Number
CR1 through CR13	Diode, FD300	FS	26012320
Q1 through Q16	Transistor, S17396	FS	26003851
R1	Resistor, fixed, 20 kΩ ±5%, ½ W	AB	02030790
R2	Resistor, fixed, 2 kΩ ±5%, ½ W	AB	02030550
R3	Same as R1		
R4	Same as R2		
R5	Same as R1		
R6	Same as R2		
R7	Same as R1		
R8	Same as R2		
R9	Same as R1		
R10	Same as R2		
R11	Same as R1		
R12	Same as R2		
R13	Same as R1		
R14	Same as R2		
R15	Same as R1		
R16	Same as R2		
R17	Same as R1		
R18	Same as R2		
R19	Same as R1		
R20	Same as R1		
R21	Same as R2		
R22	Same as R1		
R23	Same as R1		
R24	Same as R1		
R25	Same as R2		
R26	Same as R1		
R27	Same as R1		
R28	Same as R1		
R29	Same as R2		
R30	Same as R1		
R31	Same as R1		
R32	Same as R1		
R33	Same as R2		
R34	Same as R1		
R35	Resistor, fixed, 51 kΩ ±5%, ½ W	AB	02030890

Table 6-16. 1-2-2-4 Format A17 (Option 03 Only) Parts List (Cont)*

Circuit Ref.	Description	Manufacturer	Number
R36	Resistor, fixed, 39 kΩ ±5%, ½ W	AB	02030860
R37	Resistor, fixed, 3.9 kΩ ±5%, ½ W	AB	02030620
R38	Same as R1		
R39	Same as R35		
R40	Same as R36		
R41	Same as R37		
R42	Same as R1		
R43	Same as R35		
R44	Same as R36		
R45	Same as R37		
R46	Same as R1		

Table 6-17. 1-2-4-8 Format A17 (Option 04 Only) Parts List

Circuit Ref.	Description	Manufacturer	Number
CR1 through CR13	Diode, FD300	FS	26012320
Q1 through Q15	Transistor, S17396	FS	26003851
QA1	Micrologic element, μL927	FS	26012110
QA2	Same as QA1		
QA3	Micrologic element, μL915	FS	26012070
QA4	Same as QA3		
QA5	Micrologic element, μL914	FS	26010980
QA6	Same as QA1		
QA7	Same as QA1		
QA8	Same as QA3		
QA9	Same as QA3		
QA10	Same as QA5		
R1	Resistor, fixed, 20 kΩ ±5%, ¼ W	AB	02354920
R2	Resistor, fixed, 2 kΩ ±5%, ¼ W	AB	02354680
R3	Same as R1		
R4	Same as R2		
R5	Same as R1		
R6	Same as R2		
R7 through R14	Same as R1		
R15	Same as R2		
R16	Same as R1		
R17	Same as R1		
R18	Same as R1		
R19	Same as R2		
R20	Same as R1		
R21	Same as R1		
R22	Same as R1		
R23	Same as R2		
R24	Same as R1		
R25	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R26	Resistor, fixed, 3.9 kΩ ±5%, ¼ W	AB	02354750
R27	Resistor, fixed, 39 kΩ ±5%, ¼ W	AB	02354990
R28	Same as R1		
R29	Same as R25		
R30	Same as R27		

Table 6-17. 1-2-4-8 Format A17 (Option 04 Only) Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R31	Same as R26		
R32	Same as R1		
R33	Same as R25		
R34	Same as R27		
R35	Same as R26		
R36	Same as R1		

Table 6-18. Power Supply and Logic A20 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 33 μF, 100 V	Sprague	03287580
C2	Same as C1		
C3	Capacitor, fixed, .001 μF ±10%, 100 V	Aerovox	03281610
C4	Same as C1		
C5	Same as C1		
C6	Capacitor, fixed, .01 μF ±10%, 200 V	TRW	03278910
C7	Capacitor, fixed, .033 μF ±10%, 200 V	TRW	03278940
C8	Capacitor, fixed, 1.0 μF ±10%, 35 V	TRW	03282660
C9	Capacitor, fixed, 56 μF ±20%, 20 V	Kemet	03279960
CR1	Diode, 1N4005	FS	26012270
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Diode, FD100	FS	26006930
CR6	Same as CR5		
CR7	Same as CR5		
CR8	Same as CR5		
CR9	Diode, FD300	FS	26012320
CR10	Same as CR1		
CR11	Same as CR1		
CR12	Same as CR1		
CR13	Same as CR1		
CR14	Same as CR1		
CR15	Same as CR1		
CR16	Transistor, 2N708	FS	26010460
CR17	Same as CR5		
CR18	Same as CR5		
Q1	Transistor, 2N3114	FS	26008620
Q2	Transistor, 2N706	FS	26010790
Q3	Transistor, S17396	FS	26003851
Q4	Same as Q1		
Q5	Same as Q3		
Q6	Same as Q3		
Q7	Transistor, 2N914	FS	26007000
Q8	Transistor, 2N2483	FS	26010780
Q9	Same as Q1		
Q10	Same as Q8		
Q11	Same as Q1		
Q12	Same as Q3		
Q13	Transistor, TP6206	FS	26012880
Q14	Transistor, 2N3073	FS	26011430
Q15	Same as Q8		

Table 6-18. Power Supply and Logic A20 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
Q16	Same as Q8		
Q17	Transistor, 2N2369A	FS	26011140
Q18	Transistor, 2N3073	FS	26008560
Q19	Same as Q3		
Q20	Same as Q3		
Q21	Same as Q17		
QA1	Micrologic element, μL923-27	FS	26012150
QA2	Same as QA1		
R1	Resistor, fixed, 47 kΩ ±5%, ½ W	AB	02030880
R2	Resistor, fixed, 20 kΩ ±5%, ¼ W	AB	02354920
R3	Same as R2		
R4	Resistor, fixed, 11 Ω ±5%, 1 W	AB	02033010
R5	Resistor, fixed, 120 kΩ ±5%, ½ W	AB	02030980
R6	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R7	Same as R2		
R8	Resistor, fixed, 3 kΩ ±5%, ¼ W	AB	02354720
R9	Same as R2		
R10	Same as R2		
R11	Resistor, fixed, 1.5 kΩ ±5%, ¼ W	AB	02354650
R12	Same as R2		
R13	Resistor, variable, 10 kΩ	Bourns	01094810
R14	Same as R2		
R15	Same as R6		
R16	Resistor, fixed, 51 kΩ ±5%, ¼ W	AB	02355020
R17	Resistor, fixed, 5.6 kΩ ±5%, ¼ W	AB	02354790
R18	Resistor, fixed, 2.4 kΩ ±5%, ¼ W	AB	02354700
R19	Resistor, fixed, 220 Ω ±5%, ¼ W	AB	02354460
R20	Same as R16		
R21	Resistor, fixed, 2 kΩ ±5%, ¼ W	AB	02030550
R22	Same as R1		
R23	Same as R6		
R24	Same as R6		
R25	Same as R2		
R26	Same as R11		
R27	Same as R2		
R28	Same as R2		
R29	Same as R2		
R30	Resistor, fixed, 390 Ω ±5%, ¼ W	AB	02354520

Table 6-18. Power Supply and Logic A20 Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R31	Resistor, fixed, 4.3 kΩ ±5%, ¼ W	AB	02354760
R32	Resistor, fixed, 470 Ω ±5%, ¼ W	AB	02354540
R33	Same as R2		
R34	Same as R11		
R35	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R36	Same as R6		
R37	Resistor, fixed, 3.9 kΩ ±5%, ¼ W	AB	02354750
R38	Same as R6		
R39	Resistor, fixed, 3 MΩ ±5%, ¼ W	AB	02355440
R40	Resistor, fixed, 27 kΩ ±5%, 1 W	AB	02033820
R41	Same as R40		
R42	Resistor, fixed, 18 kΩ ±5%, 1 W	AB	02033780
R43	Same as R42		
R44	Resistor, fixed, 3.6 kΩ ±5%, ¼ W	AB	02354740
R45	Same as R44		
R46	Same as R44		
R47	Same as R44		
R48	Resistor, fixed, 220 kΩ ±5%, ¼ W	AB	02355170
R49	Same as R2		
R50	Resistor, fixed, 1.2 kΩ ±5%, ¼ W	AB	02354640
R51	Same as R21		

Table 6-19. Display A21 Parts List

Circuit Ref.	Description	Manufacturer	Number
DS1 through DS5	Lamp, neon, white	TEC	12013910
DS6 through DS13	Lamp, neon, K3A	GE	12013730
R1	Resistor, fixed, 150 kΩ ±5%, ½ W	AB	02031000
R2	Resistor, fixed, 68 kΩ ±5%, ½ W	AB	02030920
R3	Same as R2		
R4	Resistor, fixed, 56 kΩ ±5%, ½ W	AB	02030900
R5	Same as R4		
R6	Resistor, fixed, 47 kΩ ±5%, ½ W	AB	02030880
R7	Same as R6		
	Tube, ZM1030	Amperex	25015620

Table 6-20. Counter Display Parent A23 Parts List

Circuit Ref.	Description	Manufacturer	Number
C1	Capacitor, fixed, 500 μF, 50 V	Mallory	03279890
C2	Same as C1		
C3	Capacitor, fixed, 12 μF, 350 V	Mallory	03279880
C4	Capacitor, fixed, 4000 μF, 10 V	Mallory	03283060
XA1 through XA10	Not listed		
XA11	Connector, 22 pin, single	Viking	09064420
XA12	Connector, 22 pin, double	Viking	09064410
XA13	Same as XA12		
XA14	Same as XA12		
XA15	Same as XA11		
XA16	Same as XA11		
XA17	Same as XA12		
XA18	Same as XA11		
XA19	Same as XA11		
XA20	Same as XA12		
XA21	Connector, 28 pin, double	Viking	09064350
Q1	Transistor, 2N2369A	FS	26011140
R1	Resistor, fixed, 1.6 kΩ ±5%, ½ W	AB	02030530
R2	Resistor, fixed, 1 kΩ ±5%, ½ W	AB	02030480
R3	Resistor, fixed, 510 Ω ±5%, ½ W	AB	02030410

Table 6-21. Terminal Board TB1 Parts List

Circuit Ref.	Description	Manufacturer	Number
CR1 through CR15	Diode, FD100	FS	26006930
CR16	Not assigned		
CR17	Not assigned		
CR18	Not assigned		
CR19	Same as CR1		
CR20	Same as CR1		
CR21	Same as CR1		

Table 6-23. Clock A4 (Option 02 Only) Parts List

Circuit Ref.	Description	Manufacturer	Number
C1 through C5	Capacitor, fixed, 33 pF ±5%, 500 V	Elmenco	03175150
C6	Capacitor, fixed, .001 μF, 1000 V	CRL	03270180
C7	Capacitor, fixed, 100 pF ±5%, 500 V	Elmenco	03281320
C8	Capacitor, fixed, .001 μF ±10%, 100 V	TRW	03278790
C9	Same as C6		
C10	Capacitor, fixed, .01 μF, 50 V	CRL	03279910
C11	Same as C10		
C12	Same as C10		
CR1 through CR9	Diode, FD100	FS	26006930
Q1 through Q7	Transistor, S19815	FS	26003921
Q8	Transistor, S18174	FS	26003911
Q9	Same as Q1		
Q10 through Q19	Same as Q1		
Q20	Transistor, S17396	FS	26003851
R1 through R5	Resistor, fixed, 3.6 kΩ ±5%, ¼ W	AB	02354740
R6 through R25	Resistor, fixed, 13 kΩ ±5%, ¼ W	AB	02354880
R26 through R30	Resistor, fixed, 10 kΩ ±5%, ¼ W	AB	02354850
R31	Same as R1		
R32	Resistor, fixed, 22 kΩ ±5%, ¼ W	AB	02354930
R33	Resistor, fixed, 47 kΩ ±5%, ¼ W	AB	02355010
R34	Same as R33		
R35	Resistor, fixed, 1.5 kΩ ±5%, ¼ W	AB	02354650
R36	Resistor, fixed, 1.6 kΩ ±5%, ½ W	AB	02030530
R37	Same as R36		
R38 through R43	Resistor, fixed, 20 kΩ ±5%, ¼ W	AB	02354920

Table 6-23. Clock A4 (Option 02 Only) Parts List (Cont)

Circuit Ref.	Description	Manufacturer	Number
R44	Resistor, fixed, 75 kΩ ±5%, ¼ W	AB	02354890
R45	Same as R26		
R46	Same as R32		
R47	Same as R33		
R48	Same as R32		
R49	Resistor, fixed, 390 kΩ ±5%, ¼ W	AB	02355230
R50	Resistor, fixed, 33 kΩ ±5%, ¼ W	AB	02354970
R51	Resistor, fixed, 50 kΩ ±10%, .5 W	Bourns	01111140
R52	Resistor, fixed, 62 kΩ ±5%, ¼ W	AB	02355040
R53	Same as R26		
R54	Resistor, fixed, 20 kΩ ±10%, .5 W	Bourns	01094820
R55	Resistor, fixed, 100 kΩ ±5%, ¼ W	AB	02355090
R56	Resistor, fixed, 6.8 kΩ ±5%, ¼ W	AB	02354810
R57	Same as R32		
R58	Same as R38		
R59	Same as R38		
R60	Same as R38		
R61	Same as R55		
R62	Same as R38		
R63	Same as R38		
R64	Same as R38		
R65	Same as R26		
R66	Same as R38		
R67	Resistor, fixed, 10 kΩ ±5%, ½ W	AB	02030720
R68	Resistor, fixed, 2.2 kΩ ±5%, ½ W	AB	02030560
R69	Same as R50		
R70	Same as R50		
R71	Resistor, variable, 50 kΩ	Helipot	01095360
R72	Same as R50		
Y1	Crystal, 500KC	Filtaire	27004781

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